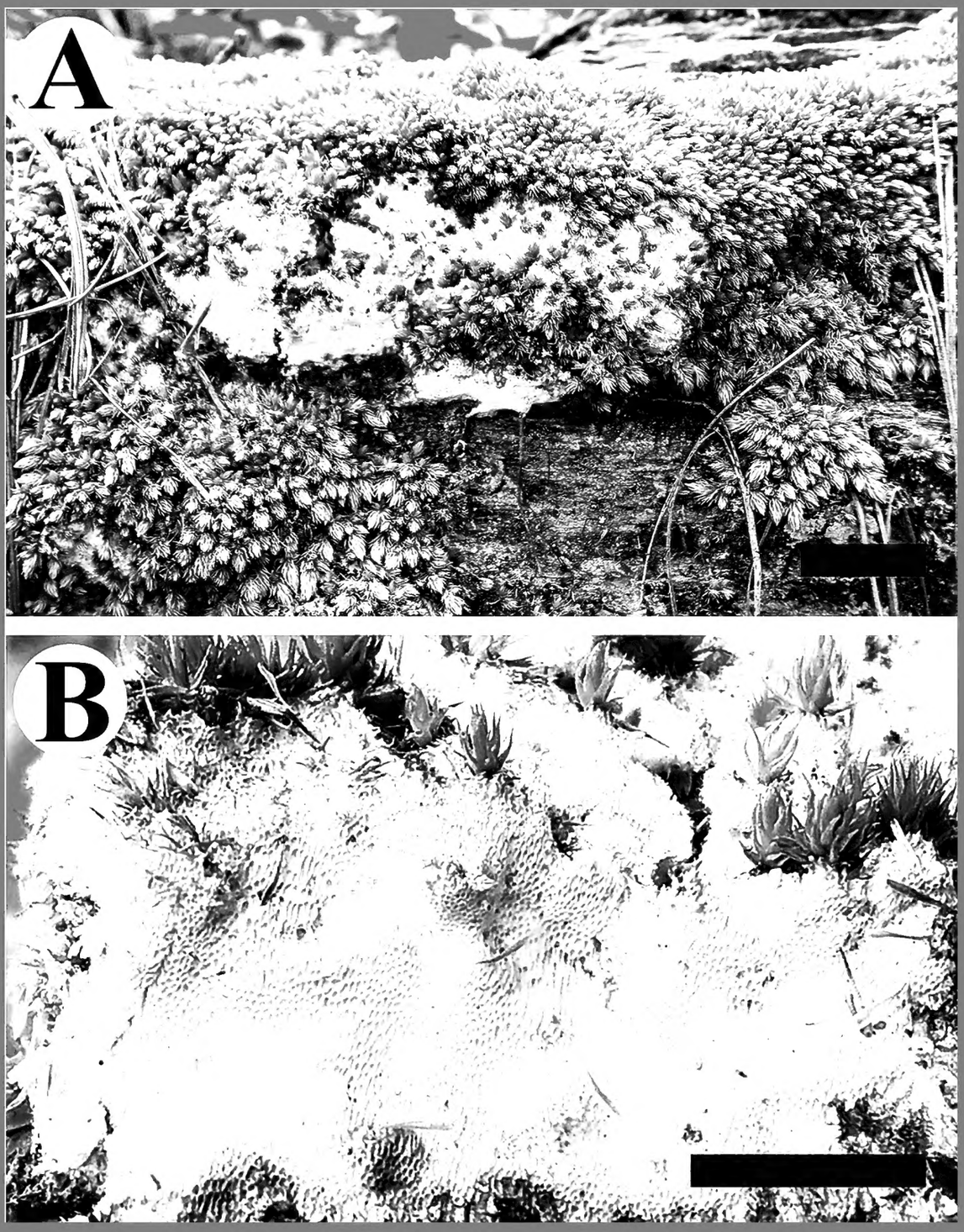
MYCOTAXON

THE INTERNATIONAL JOURNAL OF FUNGAL TAXONOMY & NOMENCLATURE

Volume 137 (2) **April–June 2022**



Cinereomyces wuliangshanensis sp. nov.

(Luo & Zhao— Fig. 2, p. 215)

ISSN (PRINT) 0093-4666 https://doi.org/10.5248/137-2 ISSN (ONLINE) 2154-8889

MYXNAE 137(2): 173–398 (2022)

ISSN 0093-4666 (print)

ISSN 2154-8889 (online)

MYCOTAXON

THE INTERNATIONAL JOURNAL OF FUNGAL TAXONOMY & NOMENCLATURE

April–June 2022

Volume 137 (2)

http://dx.doi.org/10.5248/137-2

Editor-in-Chief

Lorelei L. Norvell

editor@mycotaxon.com

Pacific Northwest Mycology Service
6720 NW Skyline Boulevard
Portland, Oregon 97229-1309 USA

Nomenclature Editor

Shaun R. Pennycook

PennycookS@LandcareResearch.co.nz

Manaaki Whenua Landcare Research
Auckland, New Zealand

www.mycotaxon.com &
www.ingentaconnect.com/content/mtax/mt
p.o. box 264, Ithaca, NY 14581-0264, USA

MYCOTAXON

VOLUME ONE HUNDRED THIRTY-SEVEN (2) — TABLE OF CONTENTS

Nomenclatural novelties & typifications vii
Corrigenda viii
Reviewers ix
From the Editor xi
2022 submission procedure xiii

New Taxa

Zasmidium sinense sp. nov. from Guangdong, China
Jing-Wen Liu, Ya-Fen Hu, Kai Zhang, Xiu-Guo Zhang, Rafael F. Castañeda-Ruíz, Jian Ma 173

Chaetocapnodium zapotae sp. nov. on *Manilkara zapota* in central Mexico
Laura Navarro-de-la-Fuente, Alejandro Salinas-Castro, Antero Ramos, Ángel Trigos 179

Xylodon flocculosus sp. nov. from Yunnan, China
Meng-Han Qu & Chang-Lin Zhao 189

Corynespora chinensis sp. nov. from Hainan, China
Jing-Wen Liu, Xiu-Guo Zhang, Rafael F. Castañeda-Ruíz, Jian Ma 203

Cinereomyces wuliangshanensis sp. nov. from China
Kai-Yue Luo & Chang-Lin Zhao 209

Gangliostilbe wuzhishanensis sp. nov. from Hainan, China
Rong-Yu Liu, Zhao-Xue Zhang, Tai-Chang Mu, Shu-Bin Liu, Xiu-Guo Zhang, Ji-Wen Xia 221

Vesiculophora diversiseptata gen. & sp. nov. and *Anapleurothecium clavatum* & *Podosporium simile* spp. nov. from the Brazilian Amazon
Josiane Santana Monteiro, Helen Maria Pontes Sotão, Miriely Cristina dos Santos Ferreira, Felipe de Jesus Rodrigues, William Kalhy Silva Xavier, De-Wei Li, Rafael F. Castañeda-Ruiz 227

Ellisembia appendiculata sp. nov. from Hainan, China
Rong-Yu Liu, Li-Guo Ma, Shu-Bing Liu, Zhao-Xue Zhang, Xiu-Guo Zhang, Ji-Wen Xia 239

Passalora sicerariae sp. nov. on
Lagenaria siceraria from India — Anu Singh, H.D. Bhartiya, P.N. Singh 245

Andomyces coronatus gen. & sp. nov. from Thailand
Veera Sri-indrasutdhi,
Charuwan Chuaseeharonnachai, Sayanh Somrithipol 251

Adustochaete yunnanensis sp. nov. from China
Yi-Fei Li & Chang-Lin Zhao 261

Erysiphe iranica sp. nov. on *Onobrychis caput-galli* in Iran
Hamideh Darsaraei, Mahdi Pirnia,
Seyed Akbar Khodaparast, Seyed Yusef Behrooz 271

Cetrarioid lichens from India revised,
including *Nephromopsis awasthii* sp. nov. and new records
Gaurav K. Mishra, Sanjeeva Nayaka, Dalip K. Upreti,
Sergii Y. Kondratyuk, Arne Thell, Ingvar Kärnefelt 283

New ranges/hosts

First record of *Lactocollybia variicystis* from Asia
Aiman Izhar, Muhammad Usman, Hira Bashir, Shazia Ashraf,
Abdul Rehman Khan Niazi, Maria Latif, Abdul Nasir Khalid 335

The first record of the coprophilous *Coemansia erecta*
in South America — Mateus Oliveira da Cruz &
André Luiz Cabral Monteiro de Azevedo Santiago 345

Anthracoidea kenaica—a new record from Russia
Teodor T. Denchev & Cvetomir M. Denchev 353

Nivicolous myxomycetes from the Navarran and French Pyrenees
A. López-Villalba, G. Moreno, M. Tapia 359

First Russian records of *Stemonitis rhizoideipes* and *Fuligo aurea,*
and newly observed morphology for *Comatricha anomala*
Anastasia V. Vlasenko, Nina V. Filippova, Vyacheslav A. Vlasenko 371

Elaphomyces leucosporus and *E. mutabilis,* new for Turkey
Yasin Uzun & Abdullah Kaya 381

Mycobiota (Funga) new to the Mycotaxon website

Current status of cercosporoid fungi of India (summary)
Shagun Sinha, Sudhir Navathe, Ravindra N. Kharwar,
Nalin N. Wijayawardene, Dong-Qin Dai, Ramesh Chand 387

Investigating the basidiomycete diversity of Grosseto province
(Italy, Tuscany): an annotated check-list (summary)
Marco Clericuzio, Diego Cantini,
Alfredo Vizzini, Francesco Dovana 389

Book reviews and notices

Lorelei L. Norvell & Else C. Vellinga 391

publication date for volume one hundred thirty-seven (1)

MYCOTAXON *for* January–March 2022 (i–xii + 1–172)
was issued on April 28, 2022

Nomenclatural novelties and typifications proposed in Mycotaxon 137(2)

Adustochaete yunnanensis C.L. Zhao
[MB 841453], p. 266

Anapleurothecium clavatum J.S. Monteiro & R.F. Castañeda
[IF557977], p. 231

Anapleurothecium leptospermi (J.A. Cooper) J.S. Monteiro & R.F. Castañeda
[IF557979], p. 233

Andomyces Chuaseehar., Sri-indr. & Somrith.
[MB823025], p. 252

Andomyces coronatus Chuaseehar., Sri-indr. & Somrith.
[MB823026], p. 252

Chaetocapnodium zapotae L. Navarro, Salinas & Trigos
[MB 837989], p. 182

Cinereomyces wuliangshanensis C.L. Zhao & K.Y. Luo
[MB 836265], p. 214

Corynespora chinensis Jing W. Liu, Jian Ma, R.F. Castañeda & X.G. Zhang
[IF 558664], p. 204

Ellisembia appendiculata J.W. Xia, R.Y. Liu & X.G. Zhang
[MB 843925], p. 240

Erysiphe iranica Darsaraei, Khodap. & Pirnia
[MB 842174] p. 276

Gangliostilbe wuzhishanensis J.W. Xia, R.Y. Liu & X.G. Zhang
[MB 843815], p. 222

Nephromopsis awasthii G.K. Mishra, Nayaka & Upreti
[MB 840586], p. 306

Passalora sicerariae Anu Singh, Bhartiya & P.N. Singh
[MB 835143], p. 246

Podosporium simile J.S. Monteiro & R.F. Castañeda
[IF557978], p. 233

Vesiculophora J.S. Monteiro & R.F. Castañeda
[IF558008], p. 228

Vesiculophora diversiseptata J.S. Monteiro & R.F. Castañeda
[IF558009], p. 229

Xylodon flocculosus C.L. Zhao
[MB 840651], p. 194

Zasmidium sinense Jing W. Liu, Jian Ma, X.G. Zhang & R.F. Castañeda
[IF 558665], p. 174

Corrigenda

Mycotaxon 137(1)

p. 21, line 19 for: Additional examinations ... ***Phaeocollybia P.***
read: Additional examinations ... ***P. spadicea***

Corrigenda for Mycotaxon 137(2)

Cited below is an omission present in files submitted for PDF conversion in the current issue but not detected by the authors until after the paper had gone to press.

p. 311, line 23 After the last sentence add: *Platismatia* is not closely related with the three other genera included in this study (Divakar et al. 2017).

Reviewers — volume one hundred thirty-seven (2)

The Editors express their appreciation to the following individuals who have, prior to acceptance for publication, reviewed one or more of the papers prepared for this issue.

Krishnendu Acharya
D. Jayarama Bhat
Uwe Braun
Rafael F. Castaneda-Ruíz
Maria Martha Dios
Arun Kumar Dutta
Daria Erastova
Edit Farkas
Patricia Oliveira Fiuza
Yang Gao
Yuehua Geng
Danny Haelewaters
Mei-Ling Han
Hsiao-Man Ho
Aamna Ishaq
Sana Jabeen
Makoto Kakishima
Ali Keleş
Munazza Kiran
Paul M. Kirk
Beeyoung Gun Lee
De-Wei Li
Jian Ma
Li-Guo Ma
José G. Marmolejo
Eric H.C. McKenzie
Josiane S. Monteiro
Lorelei L. Norvell
Giovanni Pacioni
Shaun R. Pennycook
Sergio Pérez Gorjón
Hyeon-Dong Shin
Alla V. Shnyreva
Avneet Pal Singh
Steven Lee Stephenson
Saowaluck Tibpromma
İbrahim Türkekul
Andrus Voitk

From the Editor-in-Chief

Mycotaxon style nuts and bolts—As this issue goes to press, we are in the process of editing a new set of instructions and manuscript templates to assist authors. In so doing, the supposedly helpful styles formatting of the previous Mycotaxon template will be eliminated. This past year, although it became obvious that several authors had carefully prepared manuscripts using those styles, their texts arrived at the editorial desk looking nothing like what the authors had intended. There seems to be a growing incompatibility among different computer operating systems and word processing applications that is causing problems. (The fact that one manuscript left Nomenclature Editor Pennycook's computer in perfect Times New Roman but arrived on Editor-in-Chief Norvell's computer displaying several sections written entirely in the Greek alphabet alerted us that there was trouble brewing between Shaun's Times New Roman font family on his PC and Lorelei's Times font family on her Mac.)

Therefore, until we post the 2022 author guides on our Mycotaxon website, we urge everyone to refer to the sample manuscript or a recent Mycotaxon publication for formatting suggestions. Use the current blank templates (all of which are sized for the Mycotaxon-size page) for all the required body-, legend-, and table-text files, but do not apply any built-in 'styles' or introduce your own author-defined character or paragraph styles to your document. Use instead the paragraph formatting menu built into your word-processing application. We hope to have the new guidelines available shortly!

Font-family reminder—Remember that the only font families permitted in a Mycotaxon manuscript are the serif **Times** and san-serif **Arial** families. Authors should begin any manuscripts intended for Mycotaxon using only those fonts to prevent the sudden and highly dismaying resurrection of an 'alien' font at press time.

No intervening space in °C—an editorial labor-saving device! For several years, we have advised inserting a space between the degree symbol ('°') and the temperature abbreviation ('C' or 'F'). Given the number of times scientific papers refer to temperature, it does not seem to make much sense to devote so much room to the lowly space. We feel that the degree symbol is analogous to the percent sign and that neither should be separated from its corresponding abbreviation. During editorial processing, the separate parts

frequently fall on separate lines, requiring valuable editorial time to reunite. Henceforth, we ask all of you to join our Two-Elements-Together-Movement: 20°C and 100%.

The information above might not be of high scientific interest to readers, but your Editor-in-Chief thanks you!

The 2022 April–June Mycotaxon offers 21 contributions by 89 authors (representing 17 countries) as revised by 38 expert reviewers and the editors.

With 13 titles, the new taxa section proposes two new genera (*Andomyces* from Thailand & *Vesiculophora* from Brazil) and 15 species new to science representing *Adustochaete, Cinereomyces, Corynespora, Ellisembia, Gangliostilbe, Xylodon,* and *Zasmidium* from China; *Anapleurothecium, Podosporium, Vesiculophora* from Brazil; *Andomyces* from Thailand; *Chaetocapnodium* from Mexico; *Erysiphe* from Iran; and *Nephromopsis* and *Passalora* from India. We also offer one new combination in *Anapleurothecium* from Brazil.

The New ranges/hosts section contains six titles. New species range extensions are reported for [ascomycetes] *Elaphomyces* for Turkey; [basidiomycetes] *Anthracoidea* for Russia and *Lactocollybia* for Pakistan & Asia; [myxomycetes] *Diderma, Lamproderma, Lepidoderma, Meriderma,* and *Physarum* for the French and Spanish Pyrenees and *Fuligo* & *Stemonitis* for Russia; and [zygomycetes] *Coemansia* for Brazil & South America.

Mycotaxon 137(2) also provides identification keys to species in all cetrarioid lichen genera (*Cetraria, Melanelia, Nephromopsis, Platismatia*) and species in India as well as to species in *Adustochaete, Anapleurothecium, Gangliostilbe,* and *Coemansia.* Papers providing conclusions supported by sequence analyses cover five new species representing *Adustochaete, Chaetocapnodium, Cinereomyces, Erysiphe* and *Xylodon* and one range extension in *Lactocollybia.*

We also pleased to announce the posting on our mycobiota website of two new annotated species lists, which cover 1871 Indian cercosporoid fungi in India and 1619 basidiomycetes collected from Grosseto Province in Italy. Our issue concludes with book reviews of The Hidden Kingdom of Fungi (Seifert 2022) and The Boletes of China: Tylopilus s.l. (Chun & Yang 2021).

Warm regards,

Lorelei L. Norvell (*Editor-in-Chief*)
14 July 2022

2022 Mycotaxon submission procedure

Prospective Mycotaxon authors should download the Mycotaxon 2022 guide, review & submission forms, and Mycotaxon sample manuscript by clicking the 'file download page' link on our Instructions to Authors page before preparing their manuscript. This page briefly summarizes our '4-step' submission process.

1—Peer review: Authors first contact peer reviewers (two for journal papers; three for mycobiota/fungae) before sending them formatted text & illustration files and the appropriate 2022 Mycotaxon journal or mycota reviewer comment form. Experts return revisions & comments to both the *Editor-in-Chief* <editor@mycotaxon.com> and authors. All co-authors must correct and *proof-read* their files before submitting them to the *Nomenclature Editor*.

2—Nomenclatural review: Authors email all **error-free** text, tables, legends, and graphics **in separate files** to the *Nomenclature Editor* <PennycookS@LandcareResearch.co.nz>. Place **first author surname** + **genus** + 'Mycotaxon' on the subject line, and (required) attach a completed submission form. The Nomenclature Editor will (i) immediately assign the accession number and (ii) after a few weeks return his notes and suggested revisions to the author(s) and *Editor-in-Chief*.

3—Final submission: All coauthors thoroughly revise and proof-read files to prepare error-free text and images ready for immediate publication. Poorly formatted copy will be rejected or returned for revision. E-mail the final manuscript to the *Editor-in-Chief* <editor@mycotaxon.com>, adding the **accession number** to the message and **all** files, which include a **(i)** revised 2022 submission form, all **(ii)** text files and **(iii)** jpg images, and **(iv)** FN, IF, or MB identifier verifications for each new name or typification. The *Editor-in-Chief* acknowledges submissions within two weeks of final submission but requests authors to wait at least 14 days before sending a follow-up query (without attachments).

4—Final editorial review & publication: The *Editor-in-Chief* conducts a final grammatical and scientific review and returns her editorial revisions to all expert reviewers and coauthors for final author approval. Author-approved files are placed in the publication queue.

The PDF proof and bibliographic & nomenclatural index entries are sent to all coauthors for final inspection. After PDF processing, the *Editor-in-Chief* corrects only PDF editorial/conversion and index entry errors; corrections of all other errors are listed in the Corrigenda of a subsequent issue for no charge. Authors pay fees for mycobiota uploads, optional open access, and correction of major author errors to the *Business Manager* <subscriptions@mycotaxon.com> at this time.

Mycotaxon ltd— www.mycotaxon.com

The Mycotaxon *Webmaster* <mycotaxon@gmail.com> posts announcements, subscription & publication information, and author forms & templates on the official Mycotaxon site. Our server also hosts the mycobiota web-page for free download of Fungae (regional annotated species lists).

Mycotaxon online— www.ingentaconnect.com/content/mtax/mt

The Mycotaxon journal publishes four quarterly issues per year. Both open access and subscription articles are offered.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 173–178

https://doi.org/10.5248/137.173

Zasmidium sinense sp. nov. from Guangdong, China

Jing-Wen Liu[1], Ya-Fen Hu[1], Kai Zhang[2], Xiu-Guo Zhang[3], Rafael F. Castañeda-Ruíz[4], Jian Ma[1]*

[1] *College of Agronomy, Jiangxi Agricultural University, Nanchang, Jiangxi 330045, China*

[2] *College of Forestry Engineering, Shandong Agriculture and Engineering University, Jinan, Shandong 250100, China*

[3] *Shandong Provincial Key Laboratory for Biology of Vegetable Diseases and Insect Pests, College of Plant Protection, Shandong Agricultural University, Taian, Shandong 271018, China*

[4] *Instituto de Investigaciones Fundamentales en Agricultura Tropical 'Alejandro de Humboldt' (INIFAT), Académico Titular de la "Academia de Ciencias de Cuba", Calle 1 Esq. 2, Santiago de Las Vegas, C. Habana, Cuba, C.P. 17200*

* Correspondence to: *majian821210@163.com; jxaumj@126.com*

Abstract—*Zasmidium sinense*, collected from dead branches of an unidentified broadleaf tree in Guangdong Province, China, is described and illustrated. The new species is characterized by differentiated conidiophores having a branched head with polyblastic, sympodial, conspicuously cicatrized conidiogenous cells that produce solitary, obovoid to clavate, pale brown, smooth, 1(–2)-euseptate conidia.

Key words—asexual *Ascomycota*, hyphomycetes, *Mycosphaerellaceae*, saprobes, taxonomy

Introduction

Hyphomycetous fungi are highly diverse on dead branches. They are essential components in forest ecosystems and play important roles in decomposition and nutrient recycling, but their geographical distribution and alpha taxonomy are poorly studied. Our group has investigated saprobic hyphomycetes for about 17 years during which many new genera and species have been named (e.g., Zhang & Shi 2005, Zhang & al. 2009; Xia & al. 2015; Ma & al. 2016,

2021; Zhang 2018; Xu & al. 2019, 2020). Our continuing survey of saprobic hyphomycetes from dead branches in Guangdong Province, China, revealed a previously undescribed species, proposed here as *Zasmidium sinense*.

Materials & methods

Dead branches were collected from a forested area in Liuxihe National Forest Park, Guangdong Province, China. The samples were incubated under humid conditions, and periodically examined as described by Ma & al. (2011). Microphotographs were prepared using a Nikon Eclipse E200 and SmartV550Dc digital camera, with a 100× (oil immersion) objective using the same background and scale. Adobe Photoshop 7.0 was used to assemble photographs into plates. The specimen is deposited in the Herbarium of Jiangxi Agricultural University, Plant Pathology, Nanchang, Jiangxi, China (HJAUP).

Taxonomy

Zasmidium sinense Jing W. Liu, Jian Ma, X.G. Zhang & R.F. Castañeda, **sp. nov.** FIG. 1

IF 558665

Differs from *Periconiella campograndensis*, *P. cocoes*, and *P. leptographioides* by its obovoid to clavate, pale brown, smooth, 1(–2)-euseptate, smaller or narrower conidia.

TYPE: China, Guangdong Province, Liuxihe National Forest Park, on dead branches of an unidentified broadleaf tree, 12 July 2014, J. Ma (**holotype**, HJAUP M0090).

ETYMOLOGY: referring to the country in which the fungus was collected.

COLONIES on the natural substratum effuse, dark brown. Mycelium superficial and immersed, composed of branched, septate, pale brown, smooth-walled hyphae. CONIDIOPHORES ≤265 × 4–8.5 µm, 9–20-septate, single or in groups, macronematous, mononematous, cylindrical, erect, straight or flexuous, branched towards the apex, smooth, often with 1–2 enteroblastic percurrent extensions, dark brown, paler towards the apex. Conidiogenous cells holoblastic, polyblastic, sympodial elongated, integrated and discrete in primary or secondary branches incorporated, subcylindrical to cylindrical, pale brown, bearing numerous cicatrized, protuberant loci. Conidial secession schizolytic. CONIDIA solitary, acropleurogenous, 1(–2)-euseptate, asymmetrical, obovoid to clavate, truncate and slightly melanized at the base, rounded apex, pale brown, smooth, 6–9 × 2–3 µm.

Discussion

Zasmidium Fr. was established by Fries (1849) with *Racodium cellare* Pers. [(Persoon 1794) ≡ *Zasmidium cellare* (Pers.) Fr.] as its type; the genus is currently

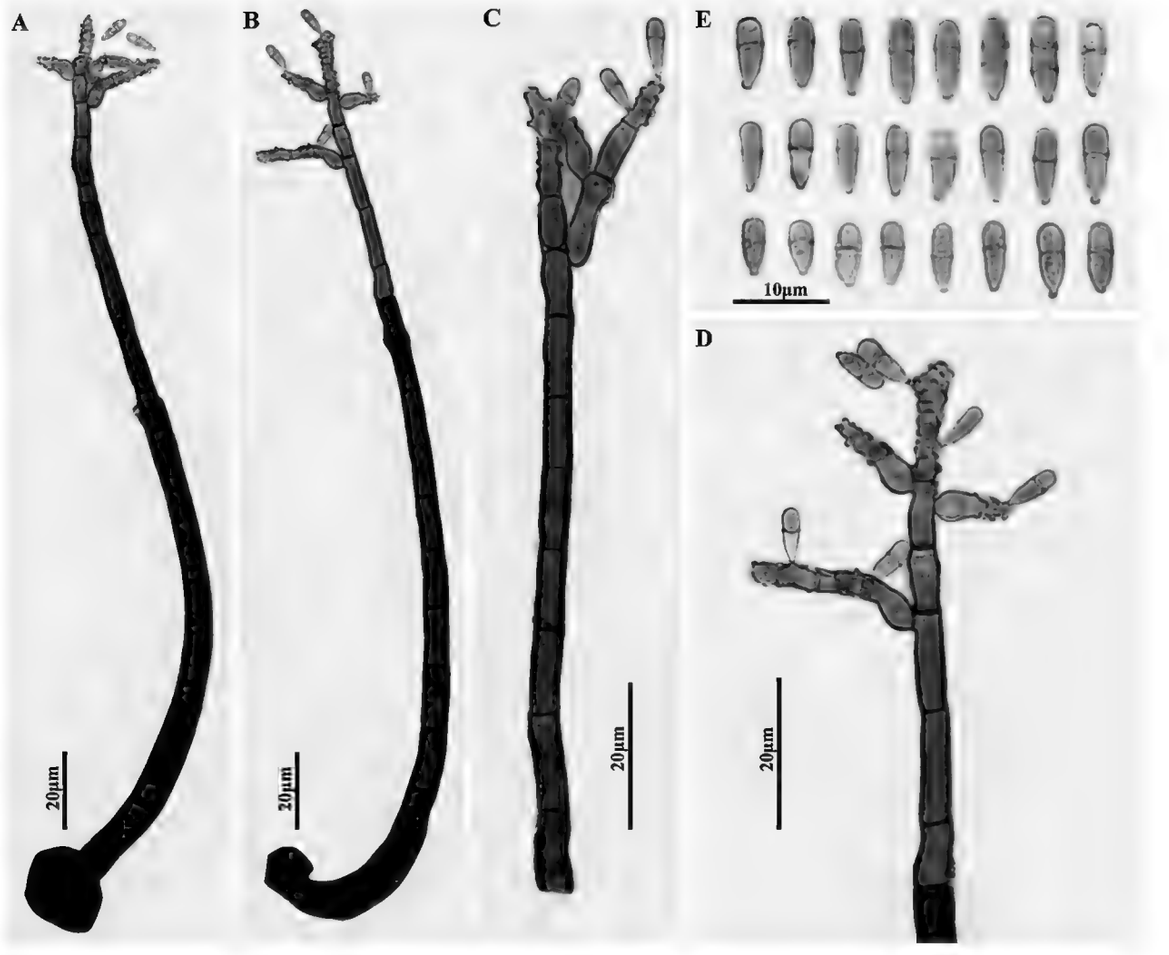


Fig. 1. *Zasmidium sinensis* (holotype, HJAUP M0090).
A–C. Conidiophores, conidiogenous cells, and conidia; D. Conidiophore head;
E. Conidia. (the pale-brown color assumed a greenish cast during processing).

placed in *Mycosphaerellaceae* Lindau based on molecular phylogenetic analysis (Arzanlou & al. 2007, Videira & al. 2017). It is morphologically characterized by semi-macronematous to macronematous conidiophores bearing polyblastic, sympodial conidiogenous cells with conspicuous, somewhat thickened and darkened-refractive, planate loci, and solitary or catenate, acropleurogenous, aseptate to pluri-euseptate conidia with a conspicuous, slightly pigmented, thickened and refractive hilum and schizolytic secession (Arzanlou & al. 2007, Seifert & al. 2011, Braun & al. 2013, Li & al. 2016, Videira & al. 2017). About 150 species are accepted in the genus (Wijayawardene & al. 2020), with most species originating from plant hosts (Shivas & al. 2010, Crous & al. 2014, Quaedvlieg & al. 2014, Zhao & al. 2016).

Zasmidium sinense exhibits the key characters of *Periconiella* Sacc. as differentiated conidiophores having a branched head with polyblastic,

sympodial, conspicuously cicatrized conidiogenous cells (Braun 2004; Braun & al. 2015; Ellis 1967; Kirschner & Piepenbring 2008; Kirschner & Chen 2010; Kirschner & Wang 2015; McKenzie 1990, 1996). Our initial thought was to place this fungus in *Periconiella*. However, Videira & al. (2017) reduced *Periconiella* to synonymy with *Zasmidium* based on the phylogenetic position and morphological characters of its type species, *P. velutina* (G. Winter) Sacc. Currently, only *P. velutina*, *P. arcuata* Arzanlou & al., and *P. musae* Stahel ex M.B. Ellis have been transferred to *Zasmidium*, whereas numerous others remain in *Periconiella* (Videira & al. 2017, Index Fungorum 2021).

Morphologically, *Zasmidium sinense* is most similar to *Periconiella campograndensis* Dorn.-Silva & Dianese, *P. cocoes* M.B. Ellis, and *P. leptographioides* B. Sutton. *Periconiella campograndensis* differs by its elliptical, verrucose, hyaline to pale brown, aseptate, larger conidia (7–15 × 4–6 µm; Dornelo-Silva & Dianese 2003); *P. cocoes* differs by its obclavate or shortly clavate, smooth or minutely verruculose, versicolored, wider (3–4 µm wide) conidia with a thicker and subglobose upper cell (Ellis 1967); and *P. leptographioides* differs by its ovoid to obovoid, verruculose, medianly 1-euseptate, larger conidia (10–12.5 × 4–5 µm; Sutton 1993).

Zasmidium sinense is also morphologically similar to *Thysanorea* Arzanlou & al. (Arzanlou & al. 2007) in the branched conidiophores. However, the conidiophores of *Thysanorea* have a complex head comprising ≤six levels of branches (Arzanlou & al. 2007), while the branching in *Zasmidium sinense* is limited, with mainly primary and secondary branches.

Acknowledgments

The authors express gratitude to Dr. E.H.C. McKenzie (Manaaki Whenua – Landcare Research, Auckland, New Zealand) and Dr. Josiane S. Monteiro (Instituto Tecnológico Vale–Desenvolvimento Sustentável, Belém, Pará, Brazil) for serving as pre-submission reviewers and to Dr. Shaun Pennycook for nomenclatural review and Dr. Lorelei L. Norvell for editorial review. This project was supported by the National Natural Science Foundation of China (Nos. 31970018, 32160006, 31360011).

Literature cited

Arzanlou M, Groenewald JZ, Gams W, Braun U, Shin HD, Crous PW. 2007. Phylogenetic and morphotaxonomic revision of *Ramichloridium* and allied genera. Studies in Mycology 58: 57–93. https://doi.org/10.3114/sim.2007.58.03

Braun U. 2004. *Periconiella* species occurring on ferns. Feddes Repertorium 115: 50–55. https://doi.org/10.1002/fedr.200311025

Braun U, Nakashima C, Crous PW. 2013. Cercosporoid fungi (*Mycosphaerellaceae*) 1. Species on other fungi, *Pteridophyta* and *Gymnospermae*. IMA Fungus 4: 265–345. https://doi.org/10.5598/imafungus.2013.04.02.12

Braun U, Bien S, Honig L, Heuchert B. 2015. *Periconiella liquidambaricola* sp. nov. – a new Chinese hyphomycete. Mycotaxon 130: 253–258. https://doi.org/10.5248/130.253

Crous PW, Shivas RG, Quaedvlieg W, van der Bank M, Zhang Y, Summerell BA, Guarro J & al. 2014. Fungal planet description sheets: 214–280. Persoonia 32: 184–306. https://doi.org/10.3767/003158514X682395

Dornelo-Silva D, Dianese JC. 2003. Hyphomycetes on the *Vochysiaceae* from the Brazilian cerrado. Mycologia 95(6): 1239–1251. https://doi.org/10.1080/15572536.2004.11833032

Ellis MB. 1967. Dematiaceous hyphomycetes. VIII. *Periconiella*, *Trichodochium*, etc. Mycological Papers 111. 46 p.

Fries EM. 1849. Summa vegetabilium Scandinaviae. Sectio posterior. Typographia Academica, Uppsala.

Index Fungorum. 2021. Fungal names search. Accessed 10 August 2021 from http://www.indexfungorum.org/names/Names.asp [a].

Kirschner R, Chen CJ. 2010. *Periconiella* species (anamorphic *Mycosphaerellaceae*) from Taiwan. Fungal Diversity 44: 135–148. https://doi.org/10.1007/s13225-010-0054-0

Kirschner R, Piepenbring M. 2008. Two new hyphomycetes parasitic on leaves of *Maianthemum* species in Panama. Mycological Progress 7: 21–29. https://doi.org/10.1007/s11557-007-0549-6

Kirschner R, Wang H. 2015. New species and records of mycosphaerellaceous fungi from living fern leaves in East Asia. Mycological Progress 14: 1–10.

https://doi.org/10.1007/s11557-015-1085-4

Li BJ, Xie XW, Shi YX, Chai AL, Guo YL. 2016. *Zasmidium oleae* sp. nov. from China. Mycotaxon 131: 791–794. https://doi.org/10.5248/131.791

Ma J, Wang Y, Ma LG, Zhang YD, Castaneda-Ruiz RF, Zhang XG. 2011. Three new species of *Neosporidesmium* from Hainan, China. Mycological Progress 10: 157–162. https://doi.org/10.1007/s11557-010-0685-2

Ma J, Zhang XG, Castañeda-Ruíz RF. 2016. *Podosporiopsis*, a new genus of synnematous hyphomycetes from China. Mycotaxon 131: 773–780. https://doi.org/10.5248/131.773

Ma J, Ma LG, Xu ZH, Cui RQ, Qiu L, Castañeda-Ruíz RF, Zhang XG. 2021. *Endophragmiella* spp. nov. and new records from southern China. Mycotaxon 136: 169–182. https://doi.org/10.5248/136.169

McKenzie EHC. 1990. New species of *Periconiella*. Mycotaxon 39: 229–236.

McKenzie EHC. 1996. A new species of *Periconiella* on *Pomaderris*. Mycotaxon 59: 43–45.

Persoon CH. 1794. Neuer Versuch einer systematischen Eintheilung der Schwämme. Neues Magazin für die Botanik 1: 63–80.

Quaedvlieg W, Binder M, Groenewald JZ, Summerell BA, Carnegie AJ, Burgess TI, Crous PW. 2014. Introducing the consolidated species concept to resolve species in the *Teratosphaeriaceae*. Persoonia 33: 1–40. https://doi.org/10.3767/003158514X681981

Seifert K, Morgan-Jones G, Gams W, Kendrick B. 2011. The genera of hyphomycetes. CBS Biodiversity Series 9. 997 p.

Shivas RG, McTaggart AR, Young AJ, Crous PW. 2010. Persoonial reflections. Persoonia 24: 127–139. https://doi.org/10.3767/003158510X512748

Sutton BC. 1993. Mitosporic fungi from Malawi. Mycological Papers 167. 93 p.

Videira SIR, Groenewald JZ, Nakashima C, Braun U, Barreto RW, de Wit PJGM, Crous PW. 2017. *Mycosphaerellaceae* – chaos or clarity? Studies in Mycology 87: 257–421. https://doi.org/10.1016/j.simyco.2017.09.003

Wijayawardene NN, Hyde KD, Al-Ani LKT, Tedersoo L, Haelewaters D, Rajeshkumar KC & al. 2020. Outline of fungi and fungus-like taxa. Mycosphere 11: 1060–1456. https://doi.org/10.5943/mycosphere/11/1/8

Xia JW, Ma YR, Gao JM, Li Z, Zhang XG. 2015. *Codinaea jianfenglingensis* sp. nov. and new records from southern China. Mycotaxon 130: 835–841. https://doi.org/10.5248/130.835

Xu ZH, Zhang K, Zhang XG, Castañeda-Ruíz RF, Ma J. 2019. *Cacumisporium fusiforme* sp. nov. from Jiangxi, China. Mycotaxon 134: 275–279. https://doi.org/10.5248/134.275

Xu ZH, Shi XG, Kuang WG, Zhang XG, Castañeda-Ruiz RF, Ma J. 2020. *Corynesporopsis hainanensis* sp. nov., a bambusicolous fungus from southern China. Mycotaxon 135: 623–630. https://doi.org/10.5248/135.623

Zhang XG. 2018. Flora fungorum sinicorum. Vol. 55. *Corynespora* et genera cognata. Science Press, Beijing.

Zhang XG, Shi CH. 2005. Taxonomic studies of *Corynespora* from China. Mycotaxon 92: 417–423.

Zhang K, Ma LG, Zhang XG. 2009. New species and records of *Shrungabeeja* from southern China. Mycologia 101: 573–578. https://doi.org/10.3852/09-006

Zhao WY, Hou YM, Bai JK, Zhang W, Gao L, Zhang R, Gleason ML, Sun GY. 2016. A new species of *Zasmidium* associated with sooty blotch and flyspeck. Phytotaxa 258(2): 190–194. https://doi.org/10.11646/phytotaxa.258.2.9

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 179–187

https://doi.org/10.5248/137.179

Chaetocapnodium zapotae sp. nov. on *Manilkara zapota* in central Mexico

Laura Navarro de la Fuente[1], Alejandro Salinas Castro[2], Antero Ramos,[3] Ángel Trigos[2]*

[1] *Posgrado en Ciencias Agropecuarias, Universidad Veracruzana, Circuito Gonzalo Aguirre Beltrán s/n, Zona Universitaria, 91090 Xalapa, Veracruz, Mexico*

[2] *Centro de Investigación en Micología Aplicada (CIMA), Universidad Veracruzana, Médicos 5, Unidad del Bosque, 91010 Xalapa, Veracruz, Mexico.*

[3] *Red Biodiversidad y Sistemática, Instituto de Ecología, A.C., P.O. Box 63, 91000, Xalapa, Veracruz, Mexico.*

* Correspondence to: *atrigos@uv.mx*

Abstract–A new sooty mould, *Chaetocapnodium zapotae,* was isolated from *Manilkara zapota* in central Veracruz, Mexico. An analysis of ITS+LSU nuclear rDNA concatenated sequences of our isolate revealed taxonomic identity at the genus level located in the same clade as *Chaetocapnodium insulare* and *Chaetocapnodium placitae*. Morphological examination confirmed that the new species differs from *C. insulare* in the absence of the sexual morph and the absence of setae on the pycnidia. Additional characters distinguishing *C. zapotae* from *C. placitae* are its narrower pycnidial size range, wider size ranges for the hyphae and conidia, and the dark brown color of its pycnidia.

Key words–*Capnodiaceae*, sapodilla fruit, *Sapotaceae*, sooty mould

Introduction

Manilkara zapota (sapodilla) is a tropical crop native to southern Mexico and Central America that is particularly valued for its anti-inflammatory, antioxidant, antimicrobial, antifungal, and anticancer properties (Khalek & al. 2015). Sapodilla orchards in central Mexico recently developed clear signs of disease involving black spots on the surface of the fruit, the cause of which

was identified as an unknown sooty mould (*Capnodiales* s.lat.). Approximately 200 species of sooty moulds have been described from many different hosts in tropical and subtropical forests. This group is characterized by the formation of a network of dark-coloured hyphae on the surface of fruits and leaves (Hughes 1976, Chomnunti & al. 2014, Hongsanan & al. 2015).

Recent extensive documentation of sooty moulds, including morphological descriptions, ecological studies, mode of nutrition, and nDNA ITS, LSU, RPB2 and TEF-1α sequence analyses have revealed the existence of a polyphyletic group covering great species diversity supported within two different classes (*Eurotiomycetes, Dothideomycetes*) and seven different orders (*Capnodiales*, *Mycosphaerellales*, *Comminutisporales*, *Cladosporiales*, *Neophaeothecales*, *Phaeothecales*, *Racodiales;* Crous & al. 2007, Abdollahzadeh & al. 2020). *Capnodiales,* considered the second largest order within *Dothideomycetes* (Abdollahzadeh & al. 2020), which includes epiphyte fungi that grow on honeydew secreted by insects or plant exudates (Hughes 1976, Crous & al. 2009, Chomnunti & al. 2014), is represented by four families (*Euantennariaceae*, *Metacapnodiaceae*, *Antennulariellaceae*, *Capnodiaceae*). The placement of *Chaetocapnodium* in *Capnodiaceae* is based on the morphology of its sexual morph and supported by LSU sequence data (Liu & al. 2015). More robust phylogenies have since revealed that some species lacking the sexual morph are congeneric with *Chaetocapnodium*, such as *Antennariella placitae,* now recombined as *Chaetocapnodium placitae* (Abdollahzadeh & al. 2020).

The main objective of this study is the morphological and genetic identification of the fungus that generates sooty mould on the epidermis of sapodilla fruits in central Mexico.

Material & methods

Sapodilla fruits were collected during May–June 2017 and 2018 from 10–12 m tall *Manilkara zapota* trees in two ~1 ha orchards close to Apazapan village located in an area of sapodilla production in Veracruz state, Mexico. Fruit samples were labeled and taken to the laboratory in the Centro de Investigación en Micología Aplicada (CIMA), Universidad Veracruzana. The samples were washed with water, and black spots on fruits were cut into small pieces (0.5 cm^2), disinfected with 2% sodium hypochlorite for 30 seconds, and washed twice with sterile water. Groups of five fruit pieces, each group separated by 2 cm, were placed 2 cm apart in Petri dishes on potato Dibico dextrose agar (PDA) containing 0.2 g/L chloramphenicol. The Petri dishes were incubated at 25 ± 2 °C for 2–3 days until samples had developed mycelia. After growth, the mycelium was carefully transferred to a new PDA + chloramphenicol agar plate and incubated under similar conditions for fungal isolation.

Table 1. Species and sequences used for the construction of the phylogenetic tree. Type specimens are annotated as [T].

Species	Voucher	GenBank No.		Country
		ITS	LSU	
Capnodium alfenasii	CBS 146151 [T]	MN749233	MN749165	Brazil
C. blackwelliae	CBS 133588 [T]	MN749235	MH878118	USA
C. coffeicola	MFLUCC15-0206 [T]	KU358921	NG_068231	Thailand
C. gamsii	CBS 892.73 [T]	MN749237	GU301847	Sri Lanka
C. neocoffeicola	CBS 139614 [T]	MN749242	MN749172	Thailand
C. paracoffeicola	CBS 139616 [T]	MN749244	MN749174	Thailand
C. salicinum	CBS 131.34	MH855469	MH866941	Indonesia
Chaetocapnodium indonesiacum	CBS 202.30 [T]	MH855113	MH866561	Indonesia
Ch. insulare	CBS 146159 [T]	NR_168830	NG_068681	South Africa
Ch. philippinense	MFLUCC12-0110 [T]	NR_168831	KP744503	Philippines
Ch. placitae	CBS 124758 [T]	MH863403	MH874920	Australia
Ch. siamense	CBS 139815	MN749252	MN749181	Thailand
Ch. summerellii	CBS 146157 [T]	NR_168829	MN749176	Australia
Ch. tanzanicum	CBS 145.79 [T]	NR_168832	MN749182	Tanzania
Ch. thailandense	CBS 139619 [T]	NR_168833	MN749183	Thailand
Ch. zapotae	CM-CNRG 938 [T]	MW258620	MW258621	Mexico
Conidiocarpus asiaticus	MFLUCC10-0062	JN832597	JN832612	Thailand
Co. siamensis	MFLUCC10-0064 [T]	KU358926	JN832609	Thailand
Heteroconium citharexyli	HM628775 [T]	HM628776	HM628775	Ecuador
Leptoxyphium citri	CBS 451.66 [T]	MN749266	KF902094	Spain
L. glochidion	IFRDCC 2651 [T]	NR_155316	KF982308	China
L. kurandae	CBS 129530 [T]	JF951150	JF951170	Australia
L. madagascariense	CBS 124766 [T]	MH863407	MH874923	Madagascar
Microxiphium leptospermi	CBS 278.34	MH855514	MH867017	Australia
Phragmocapnias betle	MFLUCC10-0053 [T]	KU358922	JN832606	Thailand
Ph. plumeriae	MFLUCC15-0205 [T]	KU358919	NG_058933	Thailand
Polychaeton citri	CBS 116435	GU214649	GU214469	Iran
P. tenellum	CBS 201.30	MH855112	MH866560	Indonesia

The hyphae and reproductive structures produced on PDA were morphologically identified using a Zeiss 1122-100 Axiostar microscope at 1000× magnification. Samples were mounted on a microscope slide with a drop of lactophenol blue solution; hyphal width, pycnidial width and height, and conidial width and height

measured (n = 50 per character). Means and standard errors (SE) are provided for sizes; extreme values are given in parentheses. Samples were compared based on previously described characters (Cheewangkoon & al. 2009, Liu & al. 2015, Abdollahzadeh & al. 2020). The holotype specimen (CM-CNRG 938, dried agar plate culture) was deposited in the Microorganism Collection of the National Center for Genetic Resources (CM-CNRG) of the National Institute of Forestry, Agricultural and Livestock Research (INIFAP) in Mexico.

Genomic DNA was extracted from fresh mycelium according to Liu & al. (2000). Amplifications of the ribosomal internal transcribed spacer region (ITS) used ITS1F/ITS4 primers (White & al. 1990, Gardes & Bruns 1993) and of the ribosomal DNA large subunit (LSU) used LR0R/LR7 primers (Vilgalys & Hester 1990). DNA was amplified in a SureCycler 8800 thermal cycler under the following conditions: initial denaturation at 94 °C for 3 min, followed by 34 cycles at 94 °C for 45 sec, 53 °C for 45 sec (ITS primers) or 55 °C for 1 min (LSU primers), followed by 72 °C for one min and final extension cycle at 72 °C for 10 min. The amplicons were processed on a 1% agarose gel at 95 V for 60 min, and the gel was stained with ethidium bromide and photographed using the Gel Doc XR + Gel Documentation System. The amplicons were purified using the Wizard® SV Gel and PCR System Clean Up kit and sent to Labsergen Langebio for sequencing on an AB3770 capillary sequencer.

The sequences were compared in the GenBank nucleotide sequence database (Benson & al. 2017) using BLAST (Zhang & al. 2000) search software to confirm the genus and percentage identity. Closely related species sequences and our newly obtained sequences were incorporated into sequence datasets independently for each molecular marker using the PhyDE v.0.9971 Phylogenetic Development Editor (Müller & al. 2010). Each dataset was independently aligned using the MAFFT online service (Katoh & al. 2019). Inconsistencies were manually adjusted and the data set of concatenated ITS+LSU sequences was integrated. The IQ-Tree program (Nguyen & al. 2015) in an online interface (Trifinopoulos & al. 2016) was used to calculate the evolutionary model (Kalyaanamoorthy & al. 2017), using the Bayesian Information Criterion (BIC) to select the best fit model. A phylogenetic tree was generated using the Maximum Likelihood (ML) method with a Nearest Neighbor Interchange (NNI) heuristic algorithm and a TNe + G4 evolutionary model. Bootstrap analysis was performed with 1000 repetitions. The resulting phylogenetic tree was visualized using FigTree v1.4.3 (Rambaut 2016). The ITS and LSU sequences generated in this study were deposited in the GenBank database, under the accession numbers provided in the taxonomic section.

Taxonomy

Chaetocapnodium zapotae L. Navarro, Salinas & Trigos, **sp. nov.** Fig. 1

MB 837989

Differs from *Chaetocapnodium insulare* by the absence of a sexual morph and the absence of setae on the pycnidia.

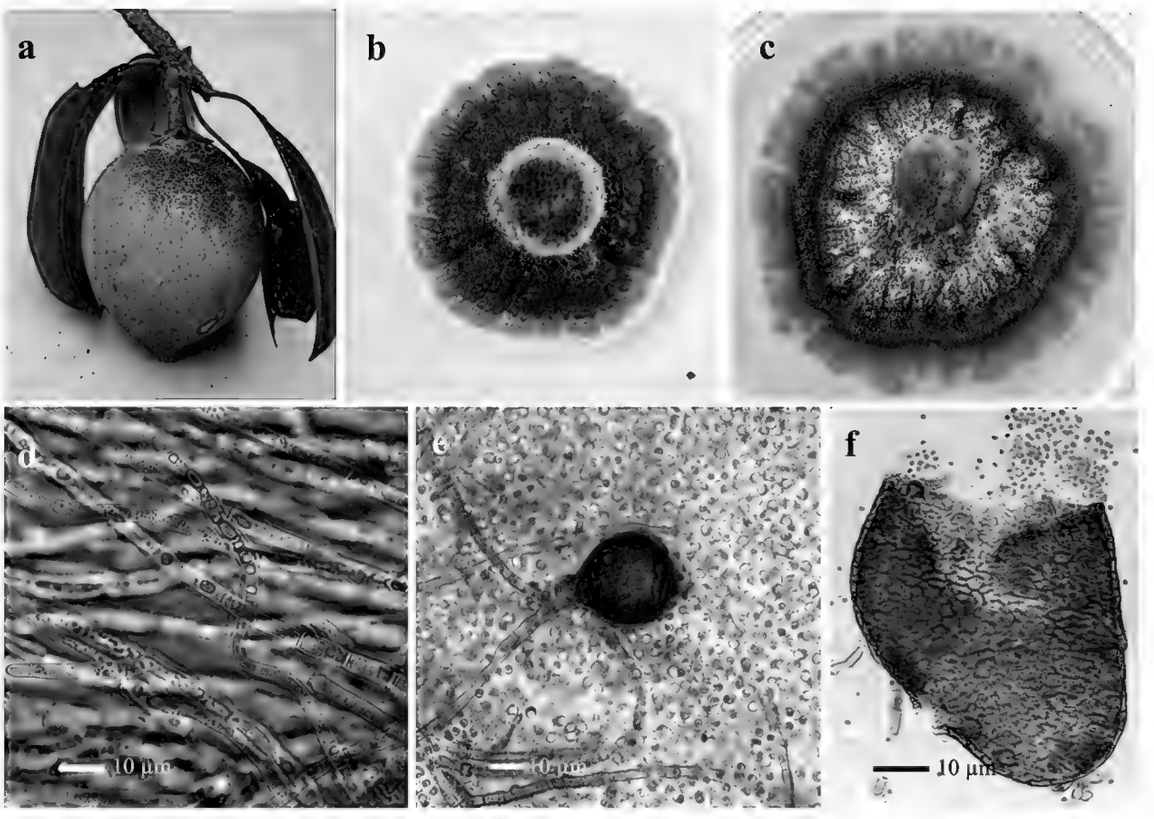


Fig. 1. *Chaetocapnodium zapotae* (holotype, CM-CNRG 938): a. Fruit of *Manilkara zapota* (sapodilla) with sooty mould on its surface; b. Mycelia grown in PDA medium for 2 wk at 25 °C in the dark; c. Mycelia cultured for 4 wks in the dark; d. Septate hyphae; e. Conidia and pycnidia; f. Irregular rupture of pycnidia releasing spores.

Type: Mexico. Veracruz State: Apazapan, 19.3381°N 96.7317°W, alt. 300 m a.s.l., on *Manilkara zapota* (L.) P. Royen (*Sapotaceae*), sapodilla fruit, Apr. 2018 (**Holotype**, CM-CNRG 938; GenBank MW258620, MW258621).

Etymology: zapotae, referring to the host plant species, *Manilkara zapota*, from which it was isolated.

Blackish fungus that grows on the exocarp surface of sapodilla fruit; Mycelium superficial or immersed, brown, septate, branched; Hyphae smooth, septate, 3.5 ± 0.1 µm wide (2–5 µm), initially hyaline, later dark brown, with a mucilaginous outer wall layer.

Pycnidia superficial or immersed, globose to subovoid, dark brown, 39.0 ± 1.7 × 32 ± 1.4 µm (21–72 × 18–58 µm), lateral, terminal or intercalary, thin-walled layers of textura angularis and a short neck; Ostiole absent or not well developed, mostly releasing conidia by means of irregular rupture at maturity; Setae not observed. Numerous conidia hyaline, globose to subglobose, with an average size 3.0 ± 0.1 × 2.5 ± 0.1 µm (2–4 × 2–4 µm), smooth and aseptate.

Sexual morph unknown.

Colonies leathery, dark brown, with fluffy aerial mycelium at the centre and creamy conidial exudates; edge sinuate with medium brown aerial mycelium after 3 wks in the dark at 25 °C; colonies reaching 12.6 mm diam on PDA after 2 wks in the dark at 25 °C.

Phylogenetic results

A phylogenetic tree was constructed with concatenated ITS+LSU sequences of 28 different species, with a final length of 1227 bp including gaps. Sequences of *Capnodium salicinum* CBS 131.34, *Microxiphium leptospermi* CBS 278.34, and *Polychaeton tenellum* CBS 201.30 were selected as outgroup (Table 1, Fig.2). Phylogenetic tree branches are indicated with their respective bootstrap values (BS) and the Bayesian posterior probabilities (BPP). Our phylogenetic tree strongly supports (100/1) our isolate as an independent species in *Chaetocapnodium* and sister to *C. insulare* and *C. placitae* (Fig. 2).

Discussion

Two other *Chaetocapnodium* species, *C. insulare* Abdollahz. & Crous and *C. placitae* (Cheew. & Crous) Abdollahz. & Crous are genetically related to *C. zapotae*. Although they share common morphological characteristics within the genus, we observed unique characteristics that support *C. zapotae* as a separate species. *Chaetocapnodium insulare* is distinguished by superficial or immersed pycnidia that are globose to pyriform, pale to dark brown, and generally small (28–)35–55 × (22–)30–48 µm; its pycnidia present setae [septate or aseptate, pale to dark brown, (7–)10–13(–19) µm] mostly around the ostiole; and its conidia are hyaline, aseptate, globose to subglobose, and longer and wider [av. = 3.4 × 3 µm; (2.8–)3.2–3.6(–4.4) × (2.6–)2.9–3.3(–3.7) µm; (Abdollahzadeh & al. 2020)] compared to other *Chaetocapnodium* species; it also presents ascomata with 3-septate brown ascospores not observed in *C. zapotae*. The radial growth rate on MEA at 25 °C is considered slow (14 mm diam/2 wk) compared to other *Chaetocapnodium* species (Abdollahzadeh & al. 2020). Nonetheless its radial growth is higher than observed for *C. zapotae* (12.6 mm diam on PDA after 2 wk in the dark at 25 °C).

The main differences between *C. zapotae* and *C. placitae* are the pycnidial coloration (brown (Fig. 1b), not medium to dark grey-brown) and a narrower pycnidial size range (21–72 × 18–58 µm; Fig. 1e, f) vs. (30–)40–60(–120) × (22–)30–40(–65) µm previously described for *C. placitae* (Cheewangkoon & al. 2009). In culture, *C. placitae* colonies exhibit an entire edge with medium to dark brownish grey woolly aerial mycelium contrasting with the sinuate

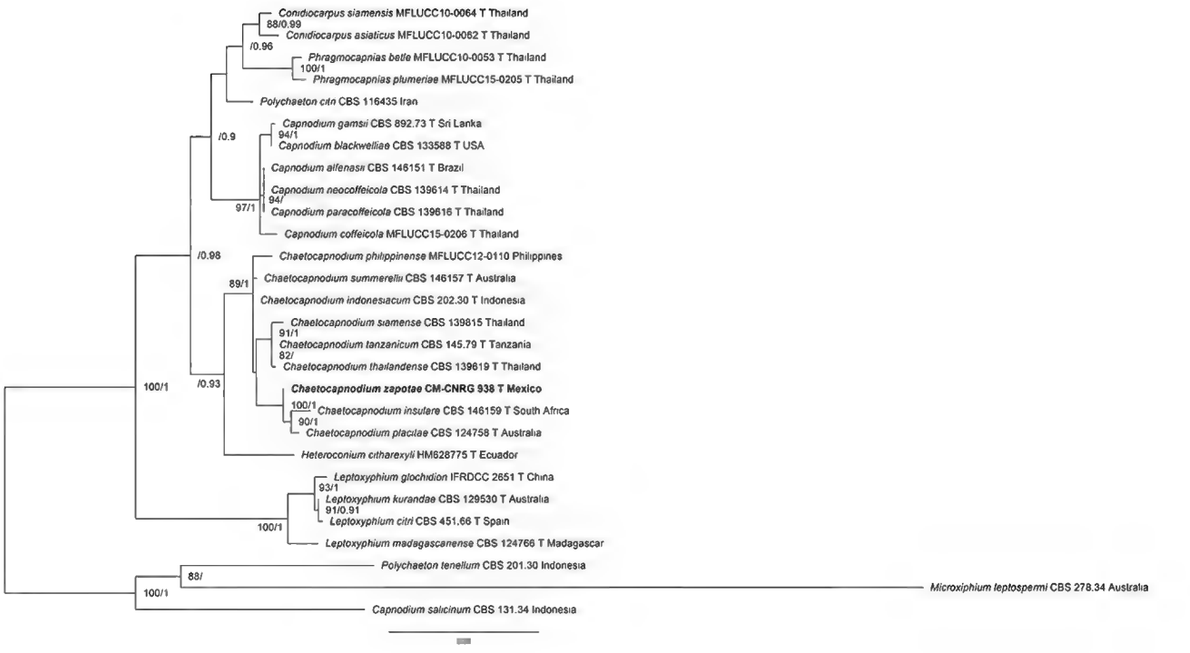


Fig. 2. Maximum likelihood phylogenetic tree generated from the analysis of the concatenated ITS+LSU sequences of the *Chaetocapnodium zapotae* (holotype, CM-CNRG 938), and closely related species downloaded from GenBank. The numbers at the nodes indicate Bootstrap values for 1000 replicates (BS ≥70%)/Bayesian Posterior Probabilities (BPP ≥0.9).

edge with medium brown aerial mycelium observed in *C. zapotae* (Fig. 1c). *Chaetocapnodium placitae* shows a more restricted size range for hyphae (range 3.5–5 µm) and conidia (2.3–)2.5–3(–3.8) × (2–)2.5–2.8(–3.2) µm when compared with *C. zapotae* hyphae (Fig. 1d). The radial growth rate of *C. placitae* on MEA at 25 °C is 20 mm diam/2 wk (Cheewangkoon & al. 2009), considerably higher than observed for *C. zapotae* in PDA. Although sexual morphology is an important characteristic within *Chaetocapnodium* (Liu & al. 2015), the sexual morph is unknown in both *C. placitae* and *C. zapotae*. However, the robust phylogeny by Abdollahzadeh & al. (2020) supports *C. placitae* in *Chaetocapnodium* despite its unknown sexual morph. and includes *C. placitae* and *C. indonesiacum* as the only two *Chaetocapnodium* species lacking setae on the pycnidia (Abdollahzadeh & al. 2020). Our phylogeny adds *C. zapotae* as a third species lacking pycnidial setae.

Our phylogenetic and morphological analyses confirm that the species is not *C. insulare* due to the absence of the sexual morph and the absence of setae on the pycnidia. Although *C. placitae* shares some similarities with our isolate, such as the absence of the sexual morph and the absence of setae on the pycnidia, *C. zapotae* is distinguished by its smaller dark brown pycnidia and its greater hyphal width and conidial width and length ranges. These

morphological differences and our new phylogeny support this isolate as a new species, which we name *Chaetocapnodium zapotae*.

We conclude that *C. zapotae* represents a new species that produces black spots on sapodilla fruits (Fig. 1a) and leaves in central Veracruz State, Mexico. This is the first report of a *Chaetocapnodium* species associated with sapodilla.

Acknowledgements

We thank Centro de Investigación en Micología Aplicada (CIMA), the Universidad Veracruzana for financial support, CONACYT for a student scholarship awarded to Laura Navarro de la Fuente and FORDECYT PRONACES/263959/2020. The authors express gratitude to Dra. Alla V. Shnyreva (Faculty of Biology, Moscow Lomonosov State University, Moscow, Russia) and Dr. José G. Marmolejo (Facultad de Ciencias Forestales, Universidad Autónoma de Nuevo León, México) for serving as pre-submission reviewers and to Dr. Shaun Pennycook for nomenclatural review and Dr. Lorelei L. Norvell for final editorial review.

Literature cited

Abdollahzadeh J, Groenewald JZ, Coetzee MPA, Wingfield MJ, Crous PW. 2020. Evolution of lifestyles in *Capnodiales*. Studies in Mycology 95: 381–414. https://doi.org/10.1016/j.simyco.2020.02.004

Benson DA, Cavanaugh M, Clark K, Karsch-Mizrachi I, Lipman DJ, Ostell J, Sayers EW. 2017. GenBank. Nucleic Acids Research 45: D37–D42. https://doi.org/10.1093/nar/gkw1070

Cheewangkoon R, Groenewald JZ, Summerell BA, Hyde KD, To-anun C, Crous PW. 2009. *Myrtaceae*, a cache of fungal biodiversity. Persoonia 23: 55–85. https://doi.org/10.3767/003158509X474752

Chomnunti P, Hongsanan S, Aguirre Hudson B, Tian Q, Peršoh D, Dhami MK, & al. 2014. The sooty moulds. Fungal Diversity 66: 1–36. https://doi.org/10.1007/s13225-014-0278-5

Crous PW, Braun U, Groenewald JZ. 2007. *Mycosphaerella* is polyphyletic. Studies in Mycology 58: 1–32. https://doi.org/10.3114/sim.2007.58.01

Crous PW, Schoch CL, Hyde KD, Wood AR, Gueidan C, de Hoog GS, Groenewald JZ. 2009. Phylogenetic lineages in the *Capnodiales*. Studies in Mycology 64: 17–47. https://doi.org/10.3114/sim.2009.64.02

Gardes M, Bruns TD. 1993. ITS primers with enhanced specificity for basidiomycetes application to the identification of mycorrhizae and rusts. Molecular Ecology 2: 113–118. https://doi.org/10.1111/j.1365-294X.1993.tb00005.x

Hongsanan S, Tian Q, Hyde KD, Chomnunti P. 2015. Two new species of sooty moulds, *Capnodium coffeicola* and *Conidiocarpus plumeriae* in *Capnodiaceae*. Mycosphere 6: 814–824. https://doi.org/10.5943/mycosphere/6/6/14

Hughes SJ. 1976. Sooty moulds. Mycologia 68: 693–820. https://doi.org/10.2307/3758799

Kalyaanamoorthy S, Minh BQ, Wong TKF, von Haeseler A, Jermiin LS. 2017. ModelFinder: fast model selection for accurate phylogenetic estimates. Nature Methods 14: 587–589. https://doi.org/10.1038/nmeth.4285

Katoh K, Rozewicki J, Yamada KD. 2019. MAFFT online service: multiple sequence alignment, interactive sequence choice and visualization. Briefings in Bioinformatics 20(4): 1160–1166. https://doi.org/10.1093/bib/bbx108

Khalek MA, Khatun Z, Habib MR, Karim MR. 2015. Antitumor activity of *Manilkara zapota* (L.) fruits against Ehrlich ascites carcinoma in mice. Biologija 61(3–4): 145–152. https://doi.org/10.6001/biologija.v61i3-4.3206

Liu D, Coloe S, Baird R, Pedersen J. 2000. Rapid mini preparation of fungal DNA for PCR. Journal of Clinical Microbiology 38(1): 471–475. https://doi.org/10.1128/JCM.38.1.471-471.2000

Liu JK, Hyde KD, Jones EBG, Ariyawansa HA, Baht DJ, Boonmee S, & al. 2015. Fungal diversity notes 1–110: taxonomic and phylogenetic contributions to fungal species. Fungal Diversity 72: 1–97. http://doi.org/10.1007/s13225-015-0324-y

Müller J, Müller K, Neinhuis C, Quandt D. 2010. PhyDE Phylogenetic Data Editor, version 0.9971. Program distributed by the authors. http://www.phyde.de

Nguyen LT, Schmidt HA, von Haeseler A, Minh BQ. 2015. IQ-TREE: a fast and effective stochastic algorithm for estimating maximum-likelihood phylogenies. Molecular Biology and Evolution 32: 268–274. https://doi.org/10.1093/molbev/msu300

Rambaut A. 2016. FigTree v1.4.3 software. Institute of Evolutionary Biology, University of Edinburgh. http://tree.bio.ed.ac.uk/software/figtree/

Trifinopoulos J, Nguyen LT, von Haeseler A, Minh BQ. 2016. W-IQ-TREE: a fast online phylogenetic tool for maximum likelihood analysis. Nucleic Acids Research 44: W232–W235. https://doi.org/10.1093/nar/gkw256

Vilgalys R, Hester M. 1990. Rapid genetic identification and mapping of enzymatically amplified ribosomal DNA from several *Cryptococcus* species. Journal of Bacteriology 172: 4239–4246. https://doi.org/10.1128/jb.172.8.4238-4246.1990

White TJ, Bruns T, Lee S, Taylor J. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. 315–322, in MA Innis & al. (eds). PCR protocols: a guide to methods and applications. Academic Press, San Diego. https://doi.org/10.1016/B978-0-12-372180-8.50042-1

Zhang Z, Schwartz S, Wagner L, Miller W. 2000. A greedy algorithm for aligning DNA sequences. Journal of Computational Biology 7: 203–214. https://doi.org/10.1089/10665270050081478

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 189–201

https://doi.org/10.5248/137.189

Xylodon flocculosus sp. nov. from Yunnan, China

Meng-Han Qu[1,3] & Chang-Lin Zhao[1,2,4*]

[1] *Key Laboratory for Forest Resources Conservation and Utilization in the Southwest Mountains of China, Ministry of Education, Southwest Forestry University, Kunming 650224, P.R. China*

[2] *College of Biodiversity Conservation, Southwest Forestry University, Kunming 650224, P.R. China*

[3] *College of Forestry, Southwest Forestry University, Kunming 650224, P.R. China*

[4] *Yunnan Key Laboratory for Fungal Diversity and Green Development, Kunming Institute of Botany, Chinese Academy of Science, Kunming 650201, China*

[*] Correspondence to: *fungichanglinz@163.com*

Abstract —A new corticioid fungal species, *Xylodon flocculosus*, is described from China based on morphological and ITS+LSU sequence analyses.

Key words — Honghe county, *Hymenochaetales*, *Schizoporaceae*, taxonomy, wood-rotting fungi

Introduction

The corticioid genus *Xylodon* (Pers.) Gray, with *X. quercinus* (Pers.) Gray as the type, is widespread. Its species are primarily wood decomposers causing white rot of both angiosperms and gymnosperms (Eriksson & Ryvarden 1976, Yurchenko & Wu 2014), although a few *Xylodon* taxa have also been collected on brown rotten spruce stumps, palms or palm tree inflorescences, bamboo, and ferns (Burdsall & al. 1981, Langer 1994, Nordén & al. 1999, Kotiranta & Saarenoksa 2000, Boidin & Gilles 2003, Hjortstam & al. 2005, Xiong & al. 2010, Jo & al. 2019). The genus is characterized by resupinate basidiomata with hymenophores that are smooth, tuberculate,

grandinioid, odontioid, coralloid, irpicoid or poroid; a monomitic hyphal system with clamp connections on generative hyphae; cystidia that are bladder-like, bottle-shaped, and capitate to subulate; suburniform basidia; and globose to ellipsoid to cylindrical basidiospores (Gray 1821, Bernicchia & Gorjón 2010). Index Fungorum (http://www.indexfungorum.org) lists 192 specific and infraspecific names in *Xylodon*, but currently accepted number of species in the genus is about 90 (Wu 1990, 2000, 2001, 2006; Xiong & al. 2009, 2010; Dai 2011, 2012; Lee & Langer 2012; Yurchenko & al. 2013; Yurchenko & Wu 2014; Zhao & al. 2014; Chen & al. 2016, 2018; Kan & al. 2017a,b; Riebesehl & Langer 2017; Wang & Chen 2017; Shi & al. 2019; Ma & Zhao 2021). About 22 *Xylodon* species have been found and described in China (Wang & Chen 2017, Shi & al. 2019, Ma & Zhao 2021, Wang & al. 2021).

Yurchenko & Wu (2014) placed *Xylodon* in the *Xylodon-Schizopora-Palifer* clade based on nuclear DNA sequence studies of *Hyphodontia* s.l. In their studies based on morphological and molecular analyses Riebesehl & Langer (2017) proposed 16 new *Xylodon* combinations. Riebesehl & al. (2019), who accept 77 species in the genus, synonymised *Palifer* Stalpers & P.K. Buchanan and *Odontiopsis* Hjortstam & Ryvarden with *Xylodon*.

We encountered an undescribed taxon during our research on corticioid fungi in southern China. Morphological comparisons and internal transcribed spacer (ITS) and large subunit nuclear ribosomal RNA gene (nLSU) sequence analyses place the fungus in *Xylodon*. The taxon is proposed here as *Xylodon flocculosus*.

Materials & methods

The studied specimens have been deposited at the herbarium of Southwest Forestry University, Kunming, Yunnan Province, P.R. China (SWFC). Macromorphological descriptions are based on field notes. Colour terms follow Petersen (1996). Micromorphological data were obtained from the dried specimens and observed under a light microscope following Dai (2012). The following abbreviations are used: KOH = 5% potassium hydroxide, CB = Cotton Blue, CB– = acyanophilous, IKI = Melzer's reagent, IKI– = both non-amyloid and non-dextrinoid, L = mean spore length (arithmetic average of all spores), W = mean spore width (arithmetic average of all spores), Q = variation in the L/W ratios between the specimens studied, n = number of spores measured/number of specimens.

CTAB rapid plant genome extraction kit-DN14 (Aidlab Biotechnologies Co., Ltd.) was used to obtain genomic DNA from dried specimens, according to the manufacturer's instructions. The ITS region was amplified with primer pairs ITS5

Table 1. *Hastodontia, Lyomyces,* and *Xylodon* species and sequences used in the phylogenetic analyses.

Species	Sample	GenBank accession no.		Reference
		ITS	LSU	
H. halonata	Mexico	MK575207	MK598738	Yurchenko & al. 2020
H. hastata	KHL14646	MH638232	MH638232	Viner & al. 2018
L. allantosporus	FR-0249548	KY800397	KY795963	Yurchenko & al. 2017
L. mascarensis	KAS-GEL 4833	KY800399	KY795964	Yurchenko & al. 2017
L. organensis	MSK 7247	KY800403	KY795967	Yurchenko & al. 2017
L. orientalis	GEL 3400	DQ340326	DQ340353	Yurchenko & al. 2017
X. apacheriensis	Wu 0910-58	KX857797	KX857822	Chen & al. 2017
X. asper	GEL 3257	EU583424	—	Yurchenko & al. 2020
X. astrocystidiatus	Wu 9211-71	JN129972	JN129973	Yurchenko & Wu 2014
X. australis	CANB869100	MT158715	MT158751	Fernández-López & al. 2020
X. borealis	Spirin 9416	MH317760	MH638259	Viner & al. 2018
X. brevisetus	KHL 12386	DQ873612	DQ873612	Larsson & al. 2006
X. bubalinus	Cui 12888	NR_154097	—	Wang & Chen 2017
X. chinensis	Wu 1407-105	KX857804	KX857811	Chen & al. 2017
X. cystidiatus	FR-0249200	MH880195	MH884896	Riebesehl & al. 2019
X. detriticus	Zíbarová 16.05.17	MH320794	—	Viner & al. 2018
X. exilis	MSK-F 7381	MH880196	MH884897	Riebesehl & al. 2019
X. filicinus	FR-0249797	MH880201	MH884901	Riebesehl & al. 2019
X. flocculosus	**CLZhao 4544**	MW980775	—	Present study
	CLZhao 18342 [T]	MW980776	MW980779	Present study
	CLZhao 18379	MW980777	MW980780	Present study
	CLZhao 18394	MW980778	MW980781	Present study
X. follis	FR-0249814	MH880204	MH884902	Riebesehl & al. 2019
X. hastifer	Ryvarden 19767	KY081801	—	Riebesehl & Langer 2017
X. heterocystidiatus	Wu 9209-27	JX175045	KX857821	Chen & al. 2017
X. hyphodontinus	LIP GG-MAR15-127	MH880208	MH884906	Riebesehl & al. 2019
X. kunmingensis	CLZhao 755	MK404530	—	Shi & al. 2019
X. lenis	Wu890714-3	KY081802	—	Riebesehl & Langer 2017
X. mollis	Wu 0808-32	JX175043	KX857820	Chen & al. 2017

Species	Sample	GenBank accession no.		Reference
		ITS	LSU	
X. mollissimus	Yuan 4391	KY007518	—	Kan & al. 2017b
X. nesporii	MA:Fungi:79920	MT158717	MT158753	Fernández-López & al. 2020
X. niemelaei	Wu 1010-62	KX857799	KX857817	Chen & al. 2017
X. nongravis	GC 1412-22	KX857801	KX857818	Chen & al. 2017
X. nothofagi	PDD: 91630	GQ411524	—	Fukami & al. 2010
X. ovisporus	SFC20180822-22	MK992859	—	Lupala & al. 2019
X. paradoxus	KAS-JR06	MH880219	—	Riebesehl & al. 2019
X. pseudotropicus	Dai 10768	NR_154066	—	Zhao & al. 2014
X. quercinus	MA:Fungi:84446	MT158719	MT158755	Fernández-López & al. 2020
X. raduloides	KAS-JR26	MH880225	MH884910	Riebesehl & al. 2019
X. reticulatus	GC 1512-1	KX857808	KX857813	Chen & al. 2017
X. rhizomorphus	Dai 12354	KF917544	—	Zhao & al. 2014
X. rimosissimus	Ryberg 021031	DQ873627	—	Larsson & al. 2006
X. serpentiformis	TUB-FO 40688	MH880229	—	Riebesehl & al. 2019
X. spathulatus	MSK-F 12931	MH884914	MH880231	Riebesehl & al. 2019
X. subclavatus	TUB-FO 42167	MH880232	—	Riebesehl & al. 2019
X. subflaviporus	Wu 0809-76	KX857803	KX857815	Chen & al. 2018
X. subtropicus	Wu 9806-105	KX857807	KX857809	Chen & al. 2017
X. verecundus	KHL 12261	DQ873642	—	Larsson & al. 2006

and ITS4 (White & al. 1990), and the nLSU region was amplified with primer pairs LR0R and LR7 (http://lutzonilab.org/nuclear-ribosomal-dna). The ITS PCR protocol was: initial denaturation at 95 °C for 3 min; then 35 cycles at 94 °C for 40 s, 58 °C for 45 s, and 72 °C for 1 min; and a final extension of 72 °C for 10 min. The nLSU PCR protocol was: initial denaturation at 94 °C for 1 min; then 35 cycles at 94 °C for 30 s, 48 °C for 1 min, and 72 °C for 1.5 min; and a final extension of 72 °C for 10 min. The PCR products were purified and directly sequenced at Kunming Tsingke Biological Technology Limited Company. All newly generated sequences were deposited at GenBank (Table 1).

Sequencher 4.6 (https://www.genecodes.com) was used to edit the DNA sequence. Sequences were aligned using the "G-INS-I" strategy in MAFFT 7 (https://mafft.cbrc.jp/alignment/server/) and manually adjusted in BioEdit (Hall 1999). The sequence alignment was deposited in TreeBase (submission ID 28085). The outgroup *Hastodontia halonata* (J. Erikss. & Hjortstam) Hjortstam & Ryvarden

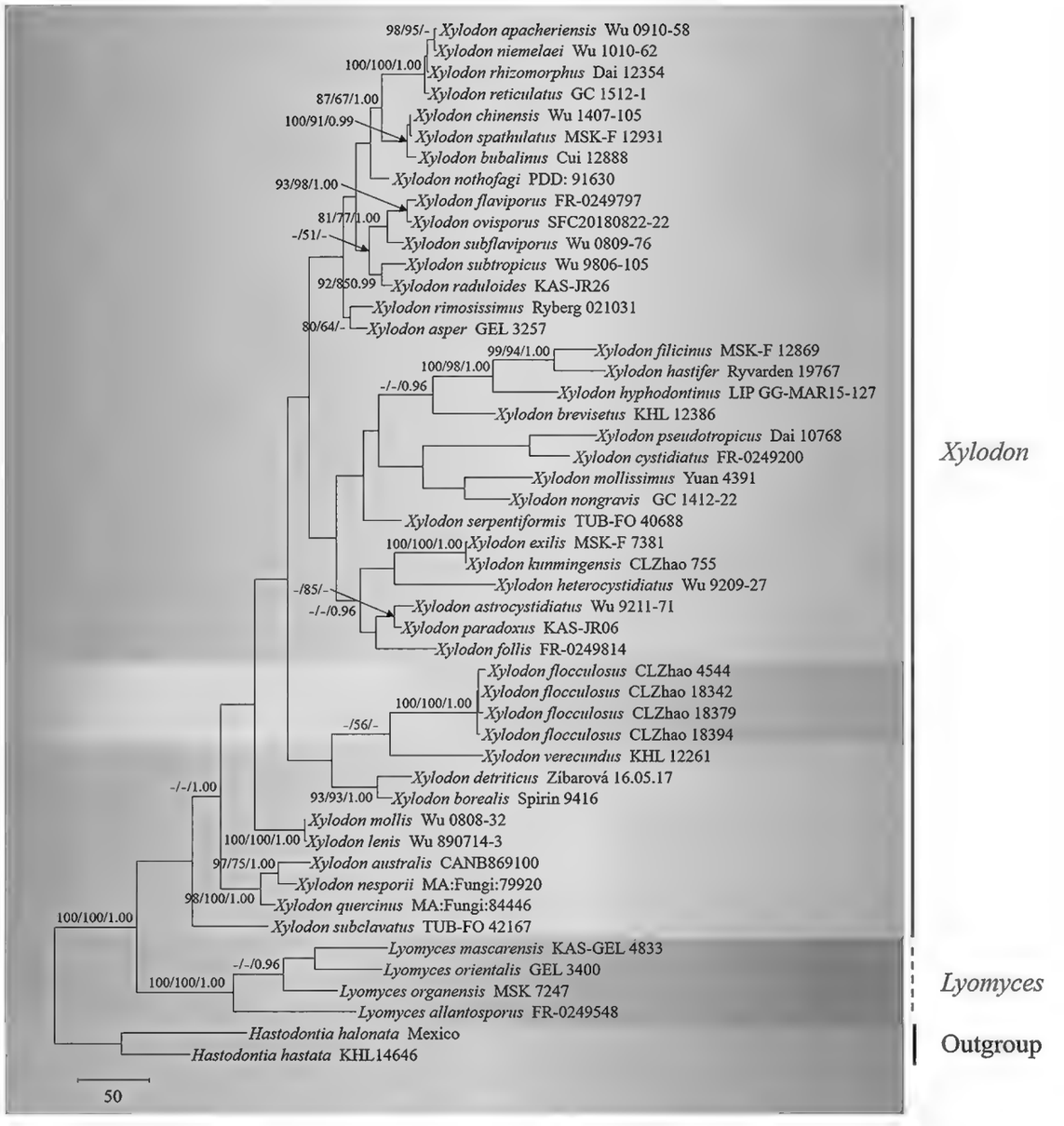


FIG. 1. Maximum parsimony strict consensus tree illustrating the phylogeny of *Xylodon flocculosus* and related species in the residual polyporoid clade, based on ITS+nLSU sequences. Branches are labeled with maximum likelihood bootstrap >70%, parsimony bootstrap proportions >50% and Bayesian posterior probabilities >0.95.

and *H. hastata* (Litsch.) Hjortstam & Ryvarden was used to root the tree in the combined analyses following Shi & al. (2019) (FIG. 1).

Maximum parsimony (MP) analysis was applied to the combined dataset sequences. Approaches to phylogenetic analysis followed Zhao & Wu (2017), and the tree was generated in PAUP* 4.0b10 (Swofford 2002). All characters were equally weighted, and gaps were treated as missing data. Trees were inferred using the heuristic search option with TBR branch swapping and 1000 random sequence additions. Max-trees were set to 5000, branches of zero length were collapsed, and all parsimonious trees were saved. Clade robustness was assessed using a bootstrap

(BT) analysis with 1000 replicates (Felsenstein 1985). Descriptive tree statistics tree length (TL), consistency index (CI), retention index (RI), rescaled consistency index (RC), and homoplasy index (HI) were calculated for each MP tree generated. Sequences were also analyzed using Maximum Likelihood (ML) with RAxML-HPC2 through the Cipres Science Gateway (www.phylo.org, Miller & al. 2009). Branch support (BS) for ML analysis was determined by 1000 bootstrap replicate.

MrModeltest 2.3 (Nylander 2004) was used to determine the best-fit evolution model for each data set for Bayesian Inference (BI). BI was calculated with MrBayes 3.1.2 with a general time reversible (GTR+I+G) model of DNA substitution and a gamma distribution rate variation across sites (Ronquist & Huelsenbeck 2003). Four Markov chains were run for 2 runs from random starting trees for 1.4 million generations, with trees sampled every 100 generations. The first one-fourth generations were discarded as burn-in. A majority rule consensus tree was calculated for all remaining trees. Branches were considered as significantly supported if they received a maximum likelihood bootstrap value (BS) >70%, maximum parsimony bootstrap value (BT) >50%, or Bayesian posterior probabilities (BPP) >0.95.

Molecular phylogeny

The combined ITS+nLSU dataset included sequences from 49 fungal specimens representing 46 taxa. The dataset had an aligned length of 2617 characters, of which 960 characters were constant, 208 parsimony-uninformative and 428 parsimony-informative. MP analysis yielded 1 equally parsimonious tree (TL = 2617, CI = 0.380, HI = 0.620, RI = 0.481, RC = 0.183). The best-fit model for ITS+nLSU alignment estimated and applied in the BI was GTR+I+G, lset nst = 6, rates = invgamma; prset statefreqpr = dirichlet (1,1,1,1). BI analysis produced a similar topology with an average standard deviation of split frequencies = 0.009310.

The phylogenetic tree (Fig. 1) inferred from ITS+nLSU sequences includes 46 *Xylodon* species. *Xylodon flocculosus* formed a well-supported distinct lineage and was sister to *X. verecundus* (G. Cunn.) Yurchenko & Riebesehl.

Taxonomy

Xylodon flocculosus C.L. Zhao, **sp. nov.** Figs 2, 3

MB 840651

Differs from *Xylodon verecundus* by its grandinoid hymenial surface and strongly encrusted cystidia.

Type: China. Yunnan Province: Honghe, Pingbian County, Daweishan National Nature Reserve, on a fallen angiosperm branch, 3 Aug 2019, CLZhao 18342 (**Holotype**, SWFC 0018342; GenBank MW980776, MW980779).

Etymology: *flocculosus* (Lat.) refers to the flocculent hymenophore of the type specimen.

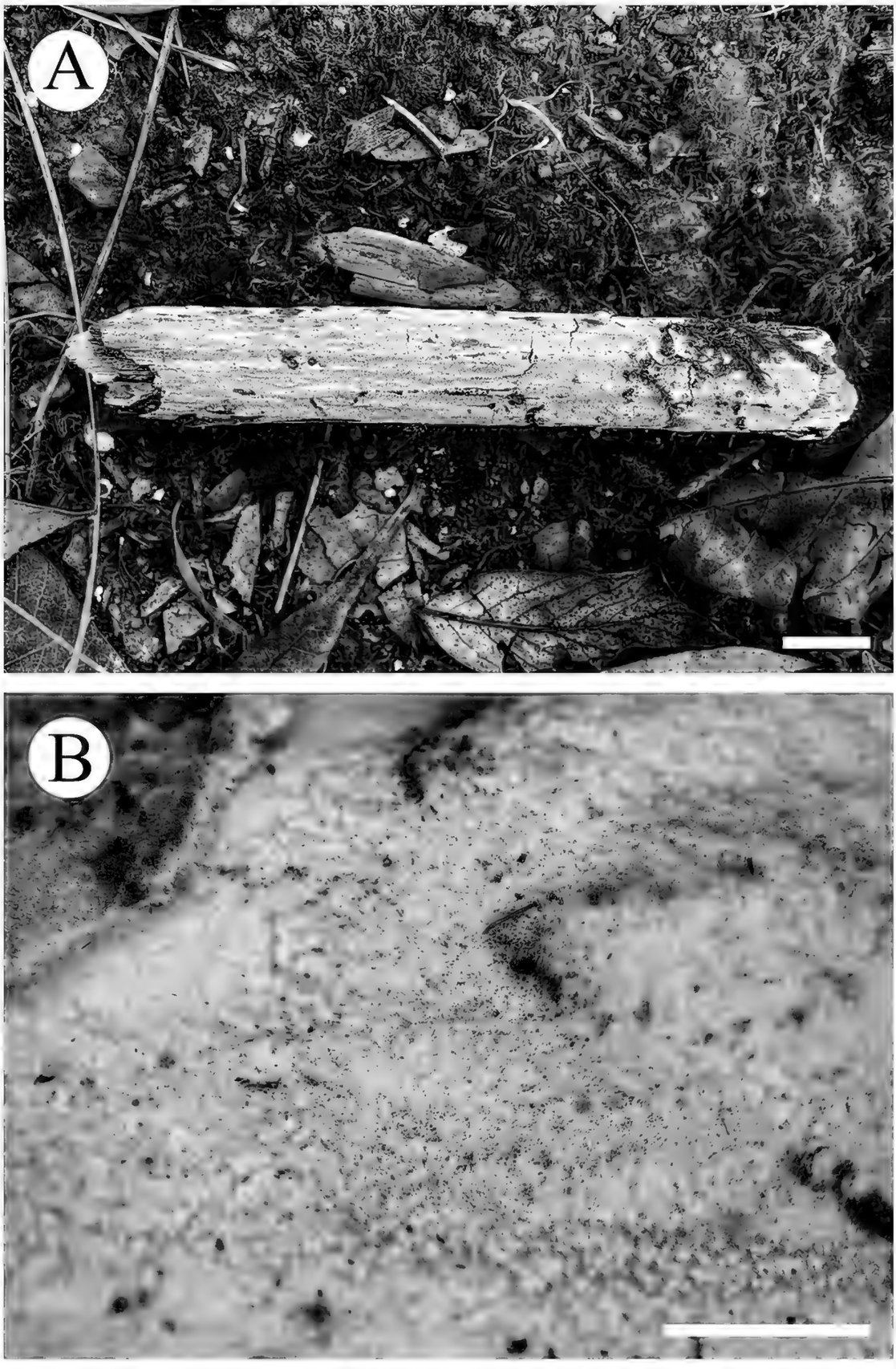


Fig. 2. *Xylodon flocculosus* (holotype, SWFC 0018342).
Basidiomata. Scale bars: A = 1 cm; B = 1 mm.

Basidiomata annual, resupinate, soft, cottony, without odor or taste when fresh, becoming flocculent on drying, ≤10 × 3 cm (length × breadth), ≤200 μm thick. Hymenial surface grandinoid, aculei 15–20 per mm, 50–100 μm long, white to pale buff when fresh, turn to buff upon drying. Margin sterile, white to pale buff, ≤1 mm wide.

Hyphal structure monomitic; generative hyphae clamped, hyaline, more or less interwoven, thick-walled, branched, 2–3 μm in diameter; IKI–, CB–, tissues unchanged in KOH.

Hymenium Cystidia numerous in the aculei, strongly encrusted at the obtuse apex, 22–55 × 2.9–5.6 μm; cystidioles absent; basidia barrel-shaped, with four sterigmata, basally clamped, slightly constricted in the middle to somewhat sinuous, 11–20 × 3.3–4.8 μm; basidioles dominant, in shape similar to basidia, but slightly smaller.

Basidiospores ellipsoid, hyaline, thick-walled, smooth, IKI–, CB–, (4–)4.2–5.7 (–6) × 3.1–4.4(–4.6) μm, L = 4.92 μm, W = 3.57 μm, Q = 1.35–1.42 (n = 120/4).

Type of rot: white rot.

Additional specimens examined: **CHINA. Yunnan province. Puer:** Jingdong County, Wuliangshan National Nature Reserve, on fallen angiosperm branch, 6 Oct 2017, CLZhao 4544 (SWFC 004544; GenBank MW980775). **Honghe:** Pingbian County, Daweishan National Nature Reserve, on fallen angiosperm branch, 3 Aug 2019, CLZhao 18379 (SWFC 018379; GenBank MW980777, MW980780) CLZhao 18394 (SWFC 018394; GenBank MW980778, MW980781).

Discussion

Earlier morphological and molecular studies (Yurchenko & Wu 2014, Riebesehl & al. 2019) strongly supported *Xylodon* as an independent genus in the *Xylodon-Schizopora-Palifer* clade. The newly described *X. flocculosus* is nested in *Xylodon* (Fig. 1) based on the combined ITS+nLSU sequence data (BS = 100%, BT = 100%, BPP = 1). The usefulness of the ITS region alone to delimit species in *Xylodon* is approaching its phylogenetic limits. Riebesehl & al. (2019) called for additional genetic markers in *Xylodon*. The present study, based on ITS and nLSU sequences, supports *X. flocculosus* within a distinct, well-supported monophyletic lineage. In ITS phylogenetic tree, *Xylodon flocculosus* was sister to *X. verecundus*. However, morphologically *X. verecundus* differs from *X. flocculosus* in its alutaceous hymenial surface, capitate cystidia, and narrower basidiospores (5 × 3 μm; Hjortstam & Ryvarden 1997).

Morphologically, *Xylodon flocculosus* resembles *X. australis* (Berk.) Hjortstam & Ryvarden, *X. rimosissimus* (Peck) Hjortstam & Ryvarden,

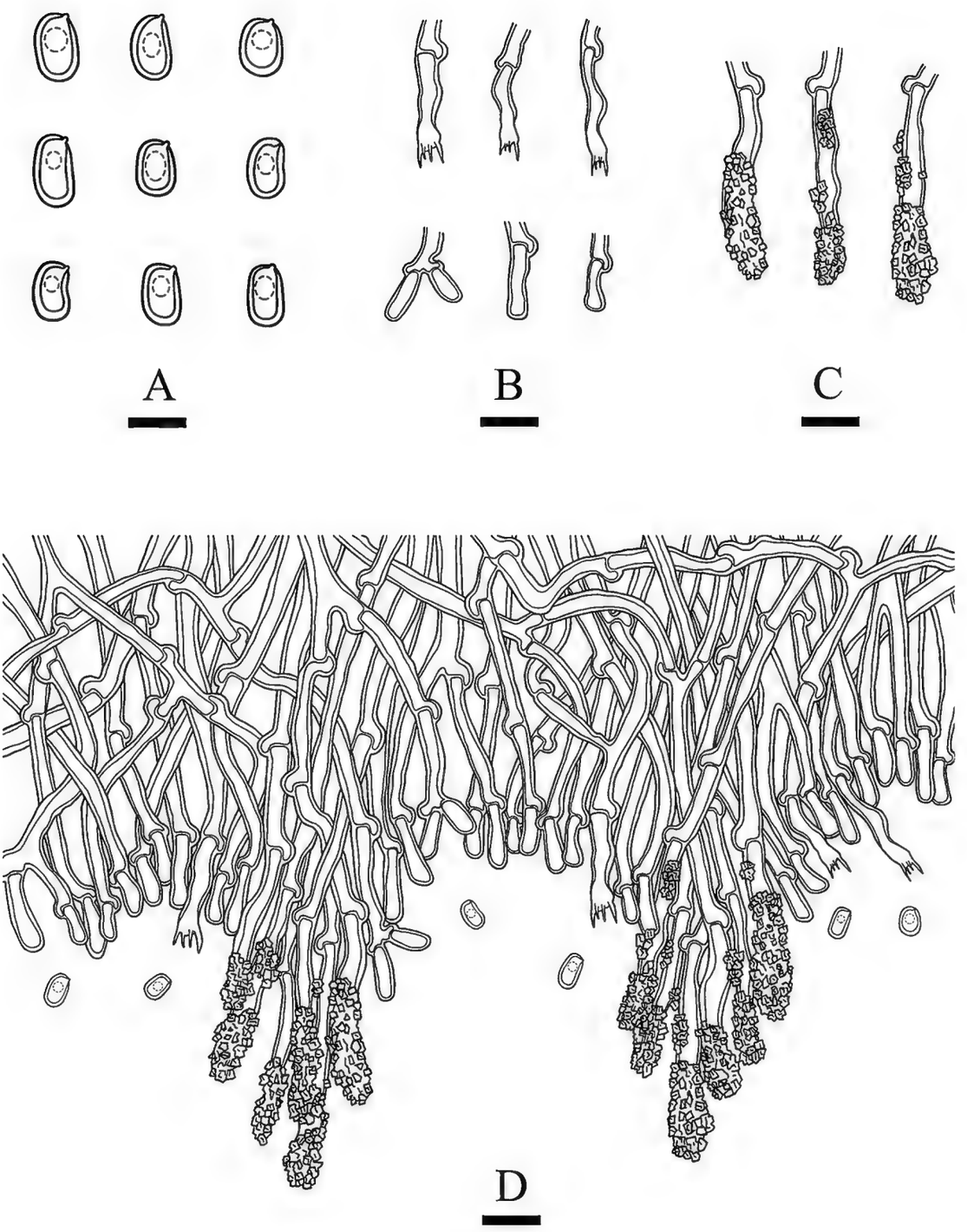


Fig. 3. *Xylodon flocculosus* (holotype, SWFC 0018342).
A. Basidiospores; B. Basidia and basidioles; C. Encrusted cystidia;
D. Section of hymenium. Scale bars: A = *5 μm;* B–D = 10 μm.

and *X. tenellus* Hjortstam & Ryvarden in sharing a grandinoid hymenial surface. *Xylodon australis* differs in having hymenophore cracked into small polygons and larger basidiospores (6–7.5 × 4–4.5 μm, Riebesehl & al. 2019);

X. rimosissimus is distinguished by its cream to beige, slightly orange hymenial surface and capitate cystidia (Langer 1994); and *X. tenellus* differs in its smaller globose basidiospores (4–4.2 × 4.2–4.5 μm, Hjortstam & Ryvarden 2007).

Xylodon fimbriatus (Sheng H. Wu) Hjortstam & Ryvarden, nom. illeg. [≡ *Lyomyces fimbriatus* (Sheng H. Wu) Riebesehl & Yurchenko (Yurchenko & al. 2020)], *X. papillosus* (Fr.) Riebesehl & al., and *X. subflaviporus* C.C. Chen & Sheng H. Wu also resemble *X. flocculosus* in having strongly encrusted cystidia. However, *X. fimbriatus* is distinguished by its limy-white hymenophore and capitate cystidia (Langer 1994), *X. papillosus* by its smooth or finely odontioid hymenophore (Rattan 1977), and *X. subflaviporus* by its poroid hymenophore with cream to straw-colored hymenial surface and apically encrusted cystidia (Chen & al. 2018).

Xylodon archeri (Berk.) Kuntze, *X. lenis* Hjortstam & Ryvarden, and *X. tuberculatus* (Kotir. & Saaren.) Hjortstam & Ryvarden are also reported with ellipsoid basidiospores. *Xylodon archeri* differs in its coralloid basidiomata with cinnamon-buff or buckthorn brown hymenial surface and presence of the capitate cystidia (Nakasone 2012), *X. lenis* in its pinkish-tinted ochraceous hymenophore and moniliform cystidia (Langer 1994), and *X. tuberculatus* in its smooth to papillose or tuberculate hymenophore and presence of gloeocystidia (Kotiranta & Saarenoksa 2000).

Acknowledgments

Special thanks are due to Drs. Avneet Pal Singh (Department of Botany, Punjabi University, Patiala, India) and Mei-Ling Han (College of Life Science, Langfang Normal University, Langfang, P.R. China) who reviewed the manuscript. The research was supported by the National Natural Science Foundation of China (Project No. 32170004), Yunnan Fundamental Research Project (Grant No. 202001AS070043), Key Laboratory of Forest Resources Conservation and Utilization in the Southwest Mountains of China Ministry of Education, Southwest Forestry University (KLESWFU-202003), and the National College Students Innovation and Entrepreneurship Training Program (No. 202110677002).

Literature cited

Bernicchia A, Gorjón SP. 2010. Fungi Europaei 12: *Corticiaceae* l. Edizioni Candusso, Lomazzo. 1007 p.

Boidin J, Gilles G. 2003. *Homobasidiomycètes Aphyllophorales* non porés à basides dominantes à 2 (3) stérigmates. Bulletin Trimestriel de la Société Mycologique de France 119: 1–17.

Burdsall HH, Nakasone KK, Freeman GW. 1981. New species of *Gloeocystidiellum* (*Corticiaceae*) from the southeastern United States. Systematic Botany 6: 422–434. https://doi.org/10.2307/2418453

Chen JJ, Zhou LW, Ji XH, Zhao CL. 2016. *Hyphodontia dimitica* and *H. subefibulata* spp. nov. (*Schizoporaceae*, *Hymenochaetales*) from southern China based on morphological and molecular characters. Phytotaxa 269: 1–13. https://doi.org/10.11646/phytotaxa.269.1.1

Chen CC, Wu SH, Chen CY. 2017. Three new species of *Hyphodontia* s.l. (*Basidiomycota*) with poroid or raduloid hymenophore. Mycological Progress 16: 553–564. https://doi.org/10.1007/s11557-017-1286-0

Chen CC, Wu SH, Chen CY. 2018. *Xylodon subflaviporus* sp. nov. (*Hymenochaetales*, *Basidiomycota*) from East Asia. Mycoscience 59: 343–352. https://doi.org/10.1016/j.myc.2017.12.004

Dai YC. 2011. A revised checklist of corticioid and hydnoid fungi in China for 2010. Mycoscience 52: 69–79. https://doi.org/10.1007/S10267-010-0068-1

Dai YC. 2012. Polypore diversity in China with an annotated checklist of Chinese polypores. Mycoscience 53: 49–80. http://doi.org/10.1007/s10267-011-0134-3

Eriksson J, Ryvarden L. 1976. The *Corticiaceae* of North Europe volume 4, *Hyphodermella*–*Mycoacia*. Fungiflora, Oslo

Felsenstein J. 1985. Confidence intervals on phylogenetics: an approach using bootstrap. Evolution 39: 783–791. https://doi.org/10.2307/2408678

Fernández-López J, Telleria MT, Dueñas M, Laguna-Castro M, Schlep K, Martín MP. 2020. Linking morphological and molecular sources to disentangle the case of *Xylodon australis*. Scientific Reports 10(22004): [14 p.]. https://doi.org/10.1038/s41598-020-78399-8

Fukami T, Dickie IA, Wilkie JP, Paulus BC, Park D, Roberts A, Buchanan PK, Allen RB. 2010. Assembly history dictates ecosystem functioning: evidence from wood decomposer communities. Ecology Letters 13: 675–648. https://doi.org/10.1111/j.1461-0248.2010.01465.x

Gray SF. 1821. A natural arrangement of British plants. London: Nabu Press.

Hall TA. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids Symposium Series 41: 95–98.

Hjortstam K, Ryvarden L. 1997. Corticioid species (*Basidiomycotina*, *Aphyllophorales*) from Colombia collected by Leif Ryvarden. Mycotaxon 64: 229–241.

Hjortstam K, Ryvarden L. 2007. Studies in corticioid fungi from Venezuela III (*Basidiomycotina*, *Aphyllophorales*). Synopsis Fungorum 23: 56–107.

Hjortstam K, Ryvarden L, Iturriaga T. 2005. Studies in corticioid fungi from Venezuela II (*Basidiomycotina*, *Aphyllophorales*). Synopsis Fungorum 20: 42–78.

Jo JW, Kwag YN, Cho SE, Han SK, Han JG, Oh S, Kim CS. 2019. *Xylodon flaviporus,* a newly recorded macrofungi in Dokdo, South Korea. Korean Journal of Mycology 47(3): 241–247. https://doi.org/10.4489/KJM.20190028

Kan YH, Gafforov Y, Li T, Zhou LW. 2017a. *Hyphodontia zhixiangii* sp. nov. (*Schizoporaceae*, *Basidiomycota*) from Uzbekistan. Phytotaxa 299: 273–279. https://doi.org/10.11646/phytotaxa.299.2.12

Kan YH, Qin WM, Zhou LW. 2017b. *Hyphodontia mollissima* sp. nov. (*Schizoporaceae*, *Hymenochaetales*) from Hainan, southern China. Mycoscience. https://doi.org/10.1016/j.myc.2017.04.003

Kotiranta H, Saarenoksa R. 2000. Three new species of *Hyphodontia* (*Corticiaceae*). Annales Botanici Fennici 37: 255–278.

Langer E. 1994. Die Gattung *Hyphodontia* John Eriksson. Bibliotheca Mycologica 154. 298 p.

Larsson KH, Parmasto E, Fischer M, Langer E, Nakasone KK, Redhead SA. 2006. *Hymenochaetales*: a molecular phylogeny for the hymenochaetoid clade. Mycologia 98: 926–936. https://doi.org/10.3852/mycologia.98.6.926

Lee IS, Langer E. 2012. New records of *Hyphodontia* species from Taiwan. Nova Hedwigia 94: 239–244. https://doi.org/10.1127/0029-5035/2012/0094-0239

Lupala AS, Oh S-Y, Park MS, Kim T, Yoo J-S, Seelan JSS, Lim YW. 2019. Co-occurrence patterns of wood-decaying fungi and ants in dead pines of South Korea. Journal of Asia-Pacific Entomology 22: 1154–1160. https://doi.org/10.1016/j.aspen.2019.10.009

Ma X, Zhao CL. 2021. *Xylodon bambusinus* and *X. xinpingensis* spp. nov. (*Hymenochaetales*) from southern China. Phytotaxa 511: 231–247. https://doi.org/10.11646/phytotaxa.511.3.3

Miller MA, Holder MT, Vos R, Midford PE, Liebowitz T, Chan L, Hoover P, Warnow T. 2009. The CIPRES Portals. CIPRES. http://www.phylo.org/sub_sections/portal. 2009-08-04. (Archived by WebCite® at https://www.webcitation.org/5imQlJeQa).

Nakasone KK. 2012. Type studies of corticioid *Hymenomycetes* (*Basidiomycota*) with aculei—part II. Czech Mycology 64: 23–42. https://doi.org/10.33585/cmy.64104

Nordén B, Appelquist T, Lindahl B, Henningsson M. 1999. Cubic rot fungi – corticioid fungi in highly brown rotted spruce stumps. Mycologia Helvetica 10: 13–24.

Nylander JAA. 2004. MrModeltest v2. Program distributed by the author. Evolutionary Biology Centre, Uppsala University, Uppsala.

Petersen JH. 1996. Farvekort. The Danish Mycological Society's colour-chart. Foreningen til Svampekundskabens Fremme, Greve.

Rattan SS. 1977. The resupinate *Aphyllophorales* of the northwestern Himalayas. Bibliotheca Mycologica 60. 427 p.

Riebesehl J, Langer E. 2017. *Hyphodontia* s.l. (*Hymenochaetales*, *Basidiomycota*): 35 new combinations and new keys to all 120 current species. Mycological Progress 16: 637–666. https://doi.org/10.1007/s11557-017-1299-8

Riebesehl J, Yurchenko E, Nakasone KK, Langer E. 2019. Phylogenetic and morphological studies in *Xylodon* (*Hymenochaetales*, *Basidiomycota*) with the addition of four new species. MycoKeys 47: 97–137. https://doi.org/10.3897/mycokeys.47.31130

Ronquist F, Huelsenbeck JP. 2003. MrBayes 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19: 1572–1574. https://doi.org/10.1093/bioinformatics/btg180

Shi ZW, Wang XW, Zhou LW, Zhao CL. 2019. *Xylodon kunmingensis* sp. nov. (*Hymenochaetales*, *Basidiomycota*) from southern China. Mycoscience 60(3): 184-188. https://doi.org/10.1016/j.myc.2019.02.002

Swofford DL. 2002. PAUP*: phylogenetic analysis using parsimony (*and other methods). Version 4.0b10. Massachusetts: Sinauer Associates.

Viner I, Spirin V, Zíbarová L, Larsson K-H. 2018. Additions to the taxonomy of *Lagarobasidium* and *Xylodon* (*Hymenochaetales*, *Basidiomycota*). MycoKeys 41: 65–90. https://doi.org/10.3897/mycokeys.41.28987

Wang M, Chen YY. 2017. Phylogeny and taxonomy of the genus *Hyphodontia* (*Hymenochaetales*, *Basidiomycota*) in China. Phytotaxa 309: 45–54. https://doi.org/10.11646/phytotaxa.309.1.4

Wang XW, May TW, Liu SL, Zhou LW. 2021. Towards a natural classification of *Hyphodontia* sensu lato and the trait evolution of basidiocarps within *Hymenochaetales* (*Basidiomycota*). Journal of Fungi 7(478): [76 p.]. https://doi.org/10.3390/jof7060478

White TJ, Bruns TD, Lee SB, Taylor JW. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. 315–322, in: MA Innis & al. (eds). PCR protocols: a guide to methods and applications. Academic Press, New York. https://doi.org/10.1016/B978-0-12-372180-8.50042-1

Wu SH. 1990. The *Corticiaceae* (*Basidiomycetes*) subfamilies *Phlebioideae*, *Phanerochaetoideae* and *Hyphodermoideae* in Taiwan. Annales Botanici Fennici 142. 123 p.

Wu SH. 2000. Studies on *Schizopora flavipora* s.l., with special emphasis on specimens from Taiwan. Mycotaxon 76: 51–66.

Wu SH. 2001. Three new species of *Hyphodontia* with poroid hymenial surface. Mycologia 93: 1019–1025. https://doi.org/10.2307/3761766

Wu SH. 2006. *Hyphodontia tubuliformis*, a new species from Taiwan. Mycotaxon 95: 185–188.

Xiong HX, Dai YC, Wu SH. 2009. Three new species of *Hyphodontia* from Taiwan. Mycological Progress 8: 165–169. https://doi.org/10.1007/s11557-009-0587-3

Xiong HX, Dai YC, Wu SH. 2010. Two new species of *Hyphodontia* from China. Mycologia 102: 918–922. https://doi.org/10.3852/09-139

Yurchenko E, Xiong HX, Wu SH. 2013. Four new species of *Hyphodontia* (*Xylodon* s.s. Hjortstam & Ryvarden, *Basidiomycota*) from Taiwan. Nova Hedwigia 96: 545–558. https://doi.org/10.1127/0029-5035/2013/0092

Yurchenko E, Wu SH. 2014. Three new species of *Hyphodontia* with peg-like hyphal aggregations. Mycological Progress 13: 533–545. https://doi.org/10.1007/s11557-013-0935-1

Yurchenko E, Riebesehl J, Langer E. 2017. Clarification of *Lyomyces sambuci* complex with the descriptions of four new species. Mycological Progress 16: 865–876. https://doi.org/10.1007/s11557-017-1321-1

Yurchenko E, Riebesehl J, Langer E. 2020. *Fasciodontia* gen. nov. (*Hymenochaetales*, *Basidiomycota*) and the taxonomic status of *Deviodontia*. Mycological Progress 19: 171–184. https://doi.org/10.1007/s11557-019-01554-7

Zhao CL, Wu ZQ. 2017. *Ceriporiopsis kunmingensis* sp. nov. (*Polyporales*, *Basidiomycota*) evidenced by morphological characters and phylogenetic analysis. Mycological Progress 16: 93–100. https://doi.org/10.1007/s11557-016-1259-8

Zhao CL, Cui BK, Dai YC. 2014. Morphological and molecular identification of two new species of *Hyphodontia* (*Schizoporaceae*, *Hymenochaetales*) from southern China. Cryptogamie Mycologie 35: 87–97. https://doi.org/10.7872/crym.v35.iss1.2014.87

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 203–207

https://doi.org/10.5248/137.203

Corynespora chinensis sp. nov. from Hainan, China

Jing-Wen Liu[1], Xiu-Guo Zhang[2],
Rafael F. Castañeda-Ruíz[3], Jian Ma[1]*

[1] *College of Agronomy, Jiangxi Agricultural University, Nanchang, Jiangxi 330045, China*

[2] *Department of Plant Pathology, Shandong Agricultural University, Taian, Shandong 271018, China*

[3] *Instituto de Investigaciones Fundamentales en Agricultura Tropical 'Alejandro de Humboldt' (INIFAT), Académico Titular de la "Academia de Ciencias de Cuba", Calle 1 Esq. 2, Santiago de Las Vegas, C. Habana, Cuba, C.P. 17200*

* Correspondence to: *majian821210@163.com; jxaumj@126.com*

Abstract—A new anamorphic fungus, *Corynespora chinensis*, is described and illustrated from a specimen collected on dead branches of an unidentified broadleaf tree in Hainan, China. The fungus is characterized by its terminal, monotretic conidiogenous cells with catenate, obclavate, pale brown, smooth, 1–5-distoseptate conidia.

Key words—*Corynesporascaceae*, *Dothideomycetes*, *Ascomycota*, hyphomycetes, taxonomy

Introduction

Corynespora was established by Güssow (1905) with type species *C. mazei* Güssow. Wei (1950), who considered *C. mazei* a synonym of the earlier name *Helminthosporium cassiicola* Berk. & M.A. Curtis, recombined it as *C. cassiicola* (Berk. & M.A. Curtis) C.T. Wei. *Corynespora* has been defined as having integrated, terminal, monotretic, determinate or percurrently extending conidiogenous cells on distinct conidiophores, and acrogenous, solitary or catenate, distoseptate phragmoconidia (Wei 1950, Ellis 1971, Seifert & al. 2011, Xu & al. 2020). Under this generic concept, more than 200 epithets for *Corynespora* are listed in Index Fungorum (2021), of which 137 are currently accepted (Siboe & al. 1999, McKenzie 2010, Hyde & al. 2020, Xu & al. 2020). Most species are reported either from living leaves or from rotten wood and

dead bark of various plant species. Only 14 species are represented by DNA sequences in GenBank.

Based on cultural studies, *Corynespora* was thought to represent the anamorph of *Corynesporasca caryotae* Sivan. [= *Corynespora calicioidea* (Berk. & Broome) M.B. Ellis] in *Corynesporascaceae* Sivan. (*Pleosporales*, *Dothideomycetes*) (Sivanesan 1996). Subsequently, Voglmayr & Jaklitsch (2017) assigned *Corynespora cassiicola* and *C. smithii* to *Corynesporascaceae* in their phylogenetic analysis and revealed the polyphyletic nature of *Corynespora* based on phylogenetic analyses and morphology.

China is considered an important and highly diverse world country (Myers & al. 2000). Its forest ecosystems have a high degree of fungal diversity, and many anamorphic fungi have been discovered there (e.g., Wu & Zhuang 2005; Ma & al. 2014, 2016, 2021; Xu & al. 2017, 2019, 2021; Zhang 2018). During our ongoing mycological survey in southern China, we collected on dead branches an interesting hyphomycete morphologically similar to *Corynespora.* The fungus, remarkably different from previously described *Corynespora* taxa, is proposed here as a new species, *C. chinensis.*

Materials & methods

Fieldwork was conducted at the end of the rainy period in the forests of Baomeiling Nature Reserve, Hainan Province, China. Samples of dead branches were processed and examined following Ma & al. (2011). Conidia and conidiophores were measured and photographed using an Olympus BX 51 microscope under a 100× (oil immersion) objective at the same background and scale. Adobe Photoshop 7.0 was used to process images and assemble photographic plates. Despite several attempts, single spore isolations did not grow on PDA at 25 °C, and therefore our description is based on morphological data. The specimen was deposited in the Herbarium of Shandong Agricultural University, Plant Pathology, Taian, Shandong, China (HSAUP).

Taxonomy

Corynespora chinensis Jing W. Liu, Jian Ma, R.F. Castañeda & X.G. Zhang, **sp. nov.** Fig. 1

IF 558664

Differs from *Corynespora acaciae* by its solitary or catenate, longer conidia; and from *C. vismiae* by its smaller conidia with 1–5 distosepta.

Type: China, Hainan Province, Changjiang city, Baomeiling Nature Reserve, on dead branches of an unidentified broadleaf tree, 9 December 2009, J. Ma (**Holotype**, HSAUP H5272).

Etymology: refers to the country in which the fungus was collected.

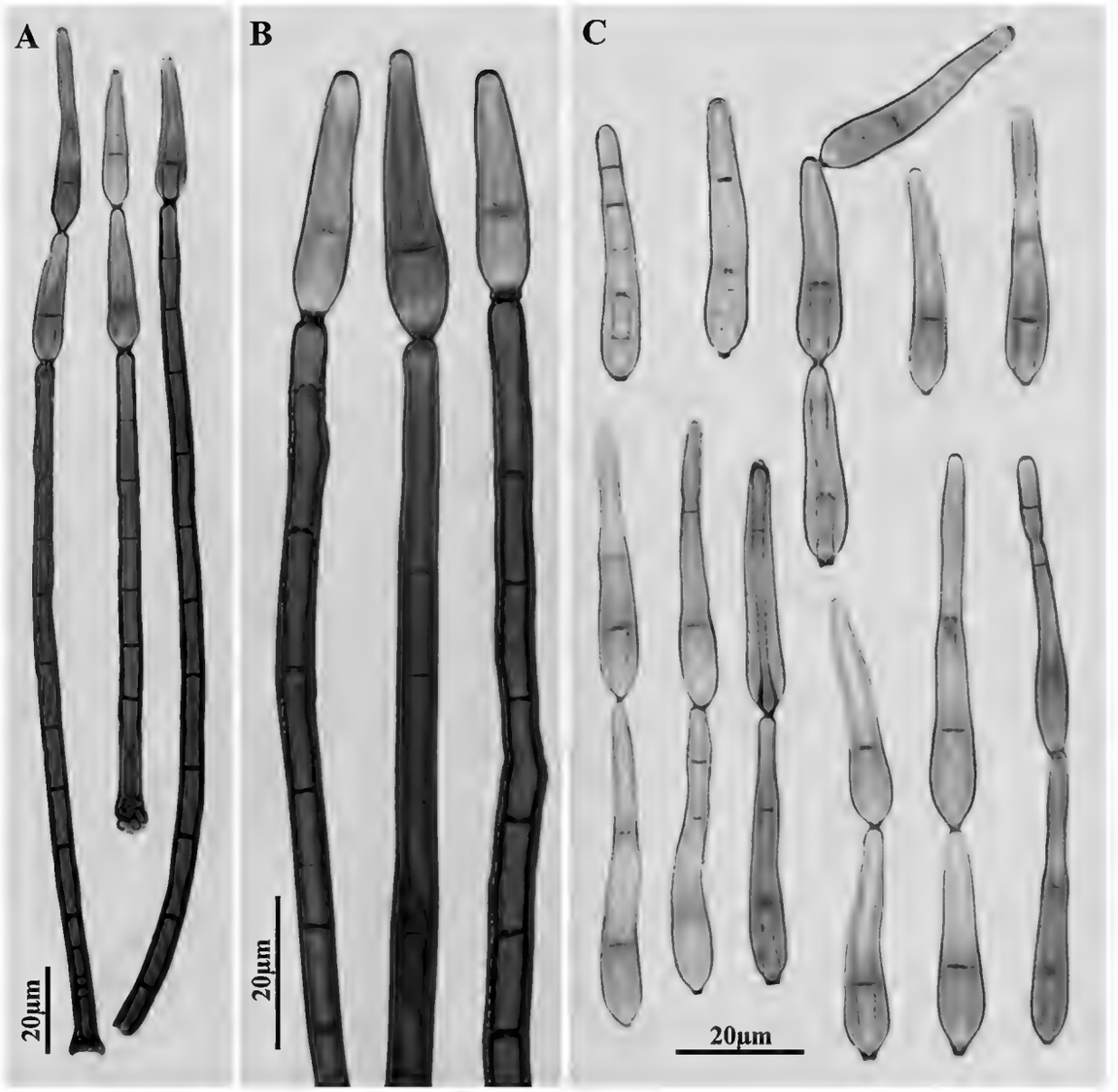


Fig. 1. *Corynespora chinensis* (holotype, HSAUP H5272).
A, B. Conidiophores, conidiogenous cells, and conidia; C. Conidia.

Colonies on dead branches effuse, brown, hairy. Mycelium superficial and immersed in the substratum composed of branched, septate, pale brown, smooth-walled hyphae. Conidiophores macronematous, mononematous, unbranched, erect, straight or flexuous, cylindrical, 5–13-septate, smooth, brown to dark brown, thick-walled, 110–290 × 4.5–7 μm. Conidiogenous cells monotretic, integrated, terminal, determinate, cylindrical, smooth, brown, 8.5–30 × 3.5–4.5 μm. Conidial secession schizolytic. Conidia acrogenous, dry, in unbranched acropetal chains, obclavate, smooth, pale brown, 1–5-distoseptate, 31–61 × 5–7.5 μm, rounded at the apex, and truncate at the base with a protuberant dark brown hilum, 1–2 μm diam.

Comments – Among *Corynespora* species, *C. chinensis* is most similar to *C. acaciae* H.J. Swart and *C. vismiae* M.B. Ellis in conidial shape, but *C. acaciae* differs by its solitary and shorter conidia (16–30 × 6–8 μm; Swart 1985), and *C. vismiae* differs by its larger conidia (55–107 × 6–9 μm, 4-distoseptate; Ellis 1963).

Acknowledgments

The authors express gratitude to Dr. De-Wei Li (The Connecticut Agricultural Experiment Station, Valley Laboratory, USA) and Dr. Patricia Oliveira Fiuza (Programa de Pós-graduação em Sistemática e Evolução, Universidade Federal do Rio Grande do Norte, Brazil) for serving as pre-submission reviewers and to Dr. Shaun Pennycook for nomenclatural review and Dr. Lorelei L. Norvell for editorial review. This project was supported by the National Natural Science Foundation of China (Nos. 32160006, 31970018, 31360011).

Literature cited

Ellis MB. 1963. Dematiaceous hyphomycetes. V. Mycological Papers 93. 33 p.

Ellis MB. 1971. Dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey, England. 608 p.

Güssow HT. 1905 ["1904"]. Notes on a disease of cucumbers. II. Journal of the Royal Agricultural Society of England 65: 271–272.

Hyde KD, de Silva NI, Jeewon R, Bhat DJ, Phookamsak R, Doilom M, Boonmee S & al. 2020. AJOM new records and collections of fungi: 1–100. Asian Journal of Mycology 3(1): 22–294. https://doi.org/10.5943/ajom/3/1/3

Index Fungorum. 2021. Fungal names search. Accessed 29 July 2021 at: http://www.indexfungorum.org/names/Names.asp

Ma J, Wang Y, Ma LG, Zhang YD, Castaneda-Ruiz RF, Zhang XG. 2011. Three new species of *Neosporidesmium* from Hainan, China. Mycological Progress 10: 157–162. https://doi.org/10.1007/s11557-010-0685-2

Ma J, Zhang XG, Castañeda-Ruíz RF. 2014. New species of *Acrodictys* and *Repetophragma* from dead branches in China. Mycotaxon 127: 129–134. https://doi.org/10.5248/127.129

Ma J, Zhang XG, Castañeda-Ruíz RF. 2016. *Podosporiopsis*, a new genus of synnematous hyphomycetes from China. Mycotaxon 131: 773–780. https://doi.org/10.5248/131.773

Ma J, Ma LG, Xu ZH, Cui RQ, Qiu L, Castañeda-Ruíz RF, Zhang XG. 2021. *Endophragmiella* spp. nov. and new records from southern China. Mycotaxon 136: 169–182. https://doi.org/10.5248/136.169

McKenzie EHC. 2010. Three new phragmosporous hyphomycetes on *Ripogonum* from an 'ecological island' in New Zealand. Mycotaxon 111: 183–196. https://doi.org/10.5248/111.183

Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853–858. https://doi.org/10.1038/35002501

Seifert K, Morgan-Jones G, Gams W, Kendrick B. 2011. The genera of hyphomycetes. CBS Biodiversity Series 9. 997 p.

Siboe GM, Kirk PM, Cannon PF. 1999. New dematiaceous hyphomycetes from Kenyan rare plants. Mycotaxon 73: 283–302.

Sivanesan A. 1996. *Corynesporasca caryotae* gen. et sp. nov. with a *Corynespora* anamorph, and the family *Corynesporascaceae*. Mycological Research 100: 783–788. https://doi.org/10.1016/S0953-7562(96)80022-0

Swart HJ. 1985. Australian leaf-inhabiting fungi. XVIII. *Corynespora acaciae* sp. nov. Transactions of the British Mycological Society 84: 175–177. https://doi.org/10.1016/S0007-1536(85)80239-4

Voglmayr H, Jaklitsch WM. 2017. *Corynespora*, *Exosporium* and *Helminthosporium* revisited – new species and generic reclassification. Studies in Mycology 87: 43–76. https://doi.org/10.1016/j.simyco.2017.05.001

Wei CT. 1950. Notes on *Corynespora*. Mycological Papers 34. 10 p.

Wu WP, Zhuang WY. 2005. *Sporidesmium*, *Endophragmiella* and related genera from China. Fungal Diversity Research Series 15. 351 p.

Xu ZH, Hu DM, Luo YQ, Ma J. 2017. Three species of *Linkosia* and *Spadicoides* new to China. Mycotaxon 132: 243–250. https://doi.org/10.5248/132.243

Xu ZH, Zhang K, Zhang XG, Castañeda-Ruíz RF, Ma J. 2019. *Cacumisporium fusiforme* sp. nov. from Jiangxi, China. Mycotaxon 134: 275–279. https://doi.org/10.5248/134.275

Xu ZH, Kuang WG, Qiu L, Zhang XG, Castañeda-Ruíz RF, Ma J. 2020. *Corynespora sinensis* sp. nov. from Jiangxi, China. Mycotaxon 135: 803–809. https://doi.org/10.5248/135.803

Xu ZH, Sun WX, Shi XG, Zhang XG, Xia JW, Castañeda-Ruíz RF, Ma J. 2021. *Camposporium chinense* sp. nov. from Jiangxi, China. Mycotaxon 136: 73–78. https://doi.org/10.5248/136.73

Zhang XG. 2018. Flora fungorum sinicorum. Vol. 55. *Corynespora* et genera cognata. Science Press, Beijing.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 209–219

https://doi.org/10.5248/137.209

Cinereomyces wuliangshanensis sp. nov. from China

Kai-Yue Luo[1,3] & Chang-Lin Zhao[1,2,3,4*]

[1] *Yunnan Key Laboratory of Plateau Wetland Conservation, Restoration and Ecological Services;*
[2] *Key Laboratory for Forest Resources Conservation and Utilization in the Southwest Mountains of China, Ministry of Education; &*
[3] *College of Biodiversity Conservation;*
[1–3] *Southwest Forestry University, Kunming, 650224, Yunnan, P.R. China*
[4] *Yunnan Key Laboratory for Fungal Diversity and Green Development, Kunming Institute of Botany, Chinese Academy of Science, Kunming 650201, Yunnan, P.R. China*

[*] Correspondence to: *fungichanglinz@163.com*

Abstract—A new poroid wood-inhabiting fungal species, *Cinereomyces wuliangshanensis,* is proposed based on morphological and molecular characters. The species is characterized by resupinate brittle basidiomata with a white pore surface, a dimitic hyphal system with clamped generative hyphae, and subglobose to broadly ellipsoid hyaline thin-walled smooth basidiospores (4.2–5.1 × 2.9–3.8 µm). Sequences were generated from the internal transcribed spacer (ITS) region of nuclear ribosomal RNA gene and phylogenetically analyzed using maximum likelihood, maximum parsimony, and Bayesian inference methods. The phylogeny strongly (100% BS, 100% BT, 1.00 BPP) supports *C. wuliangshanensis* in a monophyletic lineage grouping with *C. lindbladii* and a clade comprising *Obba rivulosa* and *O. valdiviana.*

Key words—*Gelatoporiaceae*, *Polyporales,* taxonomy, wood-inhabiting fungi, Yunnan Province

Introduction

Cinereomyces Jülich (*Gelatoporiaceae*, *Polyporales*) is characterized by resupinate poroid basidiomata with a white to cream to greyish pore surface with encrustations in trama or tube mouths, a dimitic hyphal system with clamp connections on generative hyphae, skeletal hyphae that dissolve in KOH,

cystidia absent, and basidiospores that are cylindrical to allantoid, hyaline, thin-walled, smooth, non-dextrinoid, and acyanophilous (Jülich 1982, Miettinen & Rajchenberg 2012, Ryvarden & Melo 2014). The genus, which is typified by n *C. lindbladii* (Berk.) Jülich, contains two accepted species (Jülich 1982, Miettinen 2012).

Phylogenetically, Binder & al. (2005) distributed resupinate forms across the major clades of mushroom-forming fungi and nested *Cinereomyces lindbladii* in the core polyporoid clade, grouped with *Dentocorticium sulphurellum* (Peck) M.J. Larsen & Gilb. Nuclear and mitochondrial ribosomal DNA sequences used by Tomšovský & al. (2010) grouped *C. lindbladii* with *Gelatoporia subvermispora* (Pilát) Niemelä and *Obba rivulosa* (Berk. & M.A. Curtis) Miettinen & Rajchenb. Analysis of the taxonomic relationships of four genera—*Cinereomyces*, *Gelatoporia* Niemelä, *Obba* Miettinen & Rajchenb., *Sebipora* Miettinen—nested *C. lindbladii* in the *Cinereomyces* clade, grouped with *G. subvermispora*, *O. rivulosa*, and *S. aquosa* Miettinen. Miettinen & Rajchenberg (2012) grouped *C. lindbladii* with *G. subvermispora* and *Skeletocutis amorpha* (Fr.) Kotl. & Pouzar based on their molecular analysis of *Hymenochaetales* with poroid and hydnoid hymenophores. Further molecular analyses of *Polyporales* by Binder & al. (2013) nested *C. lindbladii* within the *Gelatoporia* clade, grouping *Cinereomyces* with *Gelatoporia*, *Obba*, and *Sebipora*. A revised family-level classification of the *Polyporales* based on nrLSU, nrITS, and RPB1 genes confirmed that *Cinereomyces* belongs in *Gelatoporiaceae* Miettinen & al. (Justo & al. 2017).

During investigations on wood-inhabiting fungi in southern China, an additional taxon was found that could not be assigned to any described species. After examining the morphology and generating a phylogeny from internal transcribed spacer (ITS) region sequences, we propose a new *Cinereomyces* species.

Materials & methods

The specimens studied are deposited at the herbarium of Southwest Forestry University, Kunming, Yunnan Province, P.R. China (SWFC). Macromorphological descriptions were based on field notes. Colour terms follow Petersen (1996). Micromorphological data were obtained from the dried specimens and observed under a light microscope. Abbreviations used: KOH = 5% potassium hydroxide, CB = Cotton Blue, CB– = acyanophilous, IKI = Melzer's reagent, IKI– = both non-amyloid and non-dextrinoid, L = mean spore length (arithmetic average of all basidiospores), W = mean spore width (arithmetic average of all basidiospores), Q = variation in the L/W ratios, |n (a/b) = (a) number of basidiospores measured from (b) number of specimens.

Table 1. Species, specimens, and sequences used in this study (new sequences in **bold**).

Species name	Sample no.	GenBank no.	Reference
		ITS	
Cinereomyces lindbladii	Kotiranta 19911	FN907909	Miettinen & Rajchenberg 2012
	FBCC 117	HQ659223	Miettinen & Rajchenberg 2012
	KH Larsson 12078	FN907906	Miettinen & Rajchenberg 2012
C. wuliangshanensis	**CLZhao 3405 [T]**	MT664802	Present study
	CLZhao 3409	MT664803	Present study
Gelatoporia subvermispora	Dai 3120	HQ659226	Miettinen & Rajchenberg 2012
	Miettinen 9079	HQ659229	Miettinen & Rajchenberg 2012
	Niemela 5978	HQ659227	Miettinen & Rajchenberg 2012
	BRNU 592909	FJ496694	Miettinen & Rajchenberg 2012
	Spirin 2156	HQ659228	Miettinen & Rajchenberg 2012
	Kinnunen 1052	HQ659225	Miettinen & Rajchenberg 2012
Lopharia cinerascens	EL6397	AY463440	Miettinen & Rajchenberg 2012
Obba rivulosa	Miettinen 8054	HQ659231	Miettinen & Rajchenberg 2012
	FBCC 938	HQ659233	Miettinen & Rajchenberg 2012
	Kotiranta 16702	HQ659232	Miettinen & Rajchenberg 2012
	Penttila 14135	HQ659234	Miettinen & Rajchenberg 2012
	Penttila 14441	FJ496691	Miettinen & Rajchenberg 2012
	Penttila 15077	HQ659230	Miettinen & Rajchenberg 2012
O. valdiviana	Gates FF503	HQ659235	Miettinen & Rajchenberg 2012
	CIEFAP 336	HQ659236	Miettinen & Rajchenberg 2012
Sebipora aquosa	Miettinen 8680	HQ659240	Miettinen & Rajchenberg 2012
	Miettinen 12032	HQ659241	Miettinen & Rajchenberg 2012
	Miettinen 8868	HQ659242	Miettinen & Rajchenberg 2012
	Miettinen 9265	HQ659243	Miettinen & Rajchenberg 2012

Genomic DNA was obtained from dried specimens using a CTAB rapid plant genome extraction kit-DN14 (Aidlab Biotechnologies Co., Ltd) following the manufacturer's instructions slightly modified by grinding a small (~30 mg) dried fungal sample to powder with liquid nitrogen; the powder was transferred to a 1.5 mL centrifuge tube, suspended in 0.4 mL of lysis buffer, and incubated in a 65 °C water bath for 60 min; thereafter 0.4 mL phenol-chloroform (24:1) was added to each tube and the suspension was shaken vigorously; after centrifugation at 13,000 rpm for 5 min, 0.3 mL supernatant was transferred to a new tube and mixed with

0.45 mL binding buffer. The mixture was then transferred to an adsorbing column (AC) for centrifugation at 13,000 rpm for 0.5 min. Then, 0.5 mL inhibitor removal fluid was added in AC for a centrifugation at 12,000 rpm for 0.5 min. After washing twice with 0.5 mL washing buffer, the AC was transferred to a clean centrifuge tube, and 100 mL elution buffer was added to the middle of adsorbed film to elute the genomic DNA. The ITS region was amplified with primer pair ITS5 and ITS4 (White & al. 1990). The PCR procedure for ITS was as follows: initial denaturation at 95 °C for 3 min, followed by 35 cycles at 94 °C for 40 s, 58 °C for 45 s and 72 °C for 1 min, and a final extension of 72 °C for 10 min. The PCR products were purified and directly sequenced at Kunming Tsingke Biological Technology Limited Company. All newly generated sequences were deposited at GenBank (Table 1).

Sequencher 4.6 (GeneCodes) was used to edit the DNA sequence. Sequences were aligned in MAFFT 7 (http://mafft.cbrc.jp/alignment/server/) using the "G-INS-i" strategy and manually adjusted in BioEdit (Hall 1999). The sequence alignment was deposited in TreeBase (submission ID 26522). Sequence of *Lopharia cinerascens* (Schwein.) G. Cunn. obtained from GenBank was used as an outgroup to root tree following Miettinen & Larsson (2011) in the ITS analysis.

Maximum parsimony analysis was performed using ITS sequences dataset. Approaches to phylogenetic analysis followed Zhao & Wu (2017) and the tree construction procedure was performed in PAUP* version 4.0b10 (Swofford 2002). All characters were equally weighted, and gaps were treated as missing data. Trees were inferred using the heuristic search option with TBR branch swapping and 1000 random sequence additions. Max-trees were set to 5000, branches of zero length were collapsed, and all parsimonious trees were saved. Clade robustness was assessed using a bootstrap (BT) analysis with 1,000 replicates (Felsenstein 1985). Descriptive tree statistics tree length (TL), consistency index (CI), retention index (RI), rescaled consistency index (RC), and homoplasy index (HI) were calculated for each Maximum Parsimonious Tree (MPT). Sequences were also analyzed using Maximum Likelihood (ML) with RAxML-HPC2 through the Cipres Science Gateway (www.phylo.org; Miller & al. 2009). Branch support (BS) for ML analysis was determined by 1000 bootstrap replicates.

MrModeltest 2.3 (Nylander 2004) was used to determine the best-fit evolution model for each data set for Bayesian inference (BI). Bayesian inference was calculated with MrBayes3.1.2 with a general time reversible (GTR+I+G) model of DNA substitution and a gamma distribution rate variation across sites (Ronquist & Huelsenbeck 2003). Four Markov chains were run for 2 runs from random starting trees for 1 million generations, and trees were sampled every 100 generations. The first one-fourth generations were discarded as burn-in. A majority rule consensus tree of all remaining trees was calculated. A majority rule consensus tree of all remaining trees was calculated. Branches were considered as significantly supported if they received maximum likelihood bootstrap (BS) > 70%, maximum parsimony bootstrap (BT) >50%, or Bayesian posterior probabilities (BPP) >0.95.

Phylogenetic results

The ITS dataset (Table 1) included sequences from 24 fungal specimens representing seven taxa. The dataset had an aligned length of 570 characters, of which 417 characters were constant, 26 parsimony-uninformative, and 127 parsimony-informative. Maximum parsimony analysis yielded 1 equally parsimonious tree (TL = 213, CI = 0.869, HI = 0.151, RI = 0.959, RC = 0.832). The best-fit model for ITS alignment estimated and applied in the Bayesian was lset nst = 6, rates = invgamma; prset statefreqpr = dirichlet (1,1,1,1). Bayesian resulted in a similar topology with an average standard deviation of split frequencies = 0.009931 (BI).

The ITS phylogeny (Fig. 1) supported *Cinereomyces wuliangshanensis* as a new taxon in *Cinereomyces,* grouped with *C. lindbladii* and a clade comprising *Obba rivulosa* and *O. valdiviana* (Rajchenb.) Miettinen & Rajchenb.

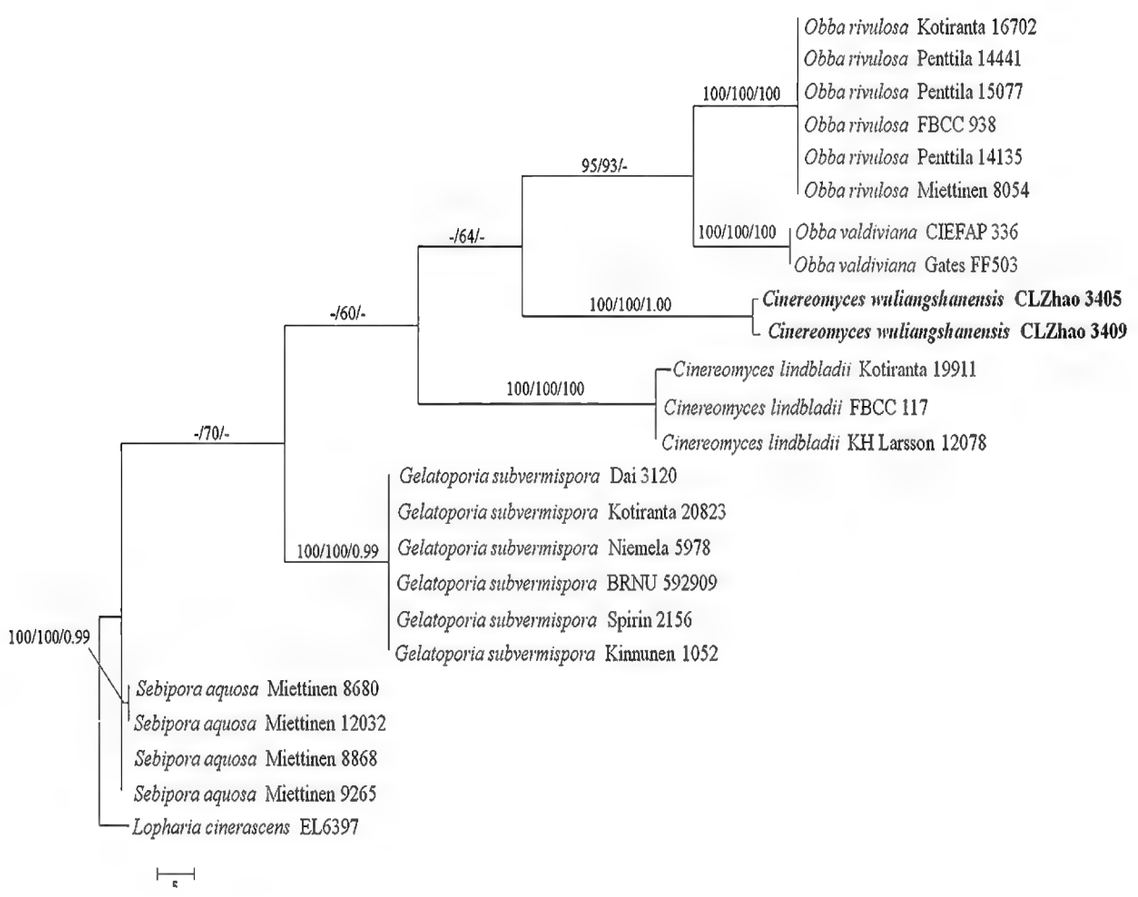


Fig. 1. Maximum Parsimony strict consensus tree illustrating the phylogeny of *Cinereomyces wuliangshanensis* and related species based on ITS sequence analyses. Branches are labeled with maximum likelihood bootstrap >70%, parsimony bootstrap proportions >50%, and Bayesian posterior probabilities >0.95.

Taxonomy

Cinereomyces wuliangshanensis C.L. Zhao & K.Y. Luo, **sp. nov.** FIGS 2, 3

MB 836265

Differs from *C. lindbladii* by its white to cream to olivaceous buff pore surface and smaller basidiospores.

TYPE: Yunnan Province, Puer, Zhenyuan County, Wuliangshan National Nature Reserve, Xieqipo Park, on angiosperm trunk, 1 October 2017, CLZhao 3405 (**Holotype**, SWFC 003405; GenBank MT664802).

ETYMOLOGY: The specific epithet *wuliangshanensis* (Lat.) refers to the collection locality (Wuliangshan) of the type specimen.

BASIDIOMATA annual, resupinate, soft, without odor or taste when fresh, becoming brittle upon drying, ≤9 cm long, 4.5 cm wide, and 1.5 mm thick at centre. Pore surface white when fresh, white to cream to olivaceous buff upon drying; pores round to elongated, 5–6 per mm; dissepiments thin, entire. Sterile margin narrow, white, ≤5 mm wide. Subiculum white, thin, ≤0.5 mm thick. Tubes white, corky, ≤1 mm long.

HYPHAL STRUCTURE dimitic; generative hyphae with clamp connections, skeletal hyphae IKI–, CB–; tissues swelling in KOH.

SUBICULUM generative hyphae hyaline, thin-walled, unbranched, 1.5–2.2 μm in diam.; skeletal hyphae rare, hyaline, thick-walled with a wide lumen, frequently branched, interwoven, 4–5 μm in diam.

TUBES generative hyphae hyaline, thin-walled, unbranched, 1–1.7 μm in diam.; skeletal hyphae dominant, hyaline, thick-walled with a wide lumen, frequently branched, interwoven, 3.5–4 μm in diam. Cystidia and cystidioles absent; basidia 15.2–16.1 × 5.1–5.3 μm, barrel-shaped, with four sterigmata and a basal clamp connection; basidioles dominant, mostly barrel-shaped, but slightly smaller than basidia.

BASIDIOSPORES (n = 60/2), (3.7–)4.2–5.1(–6.2) × (2.6–)2.9–3.8(–4.4) μm, L = 4.81 μm, W = 3.39 μm, Q = 1.40–1.43, subglobose to broadly ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–.

TYPE OF ROT: white.

ADDITIONAL SPECIMEN EXAMINED: **CHINA. YUNNAN PROVINCE. Puer:** Zhenyuan County, Wuliangshan National Nature Reserve, Xieqipo Park, on angiosperm trunk, 1 October 2017, CLZhao 3409 (SWFC 003409; GenBank MT664803).

Discussion

The current study proposes and describes a new species, *Cinereomyces wuliangshanensis,* based on phylogenetic and morphological analyses.

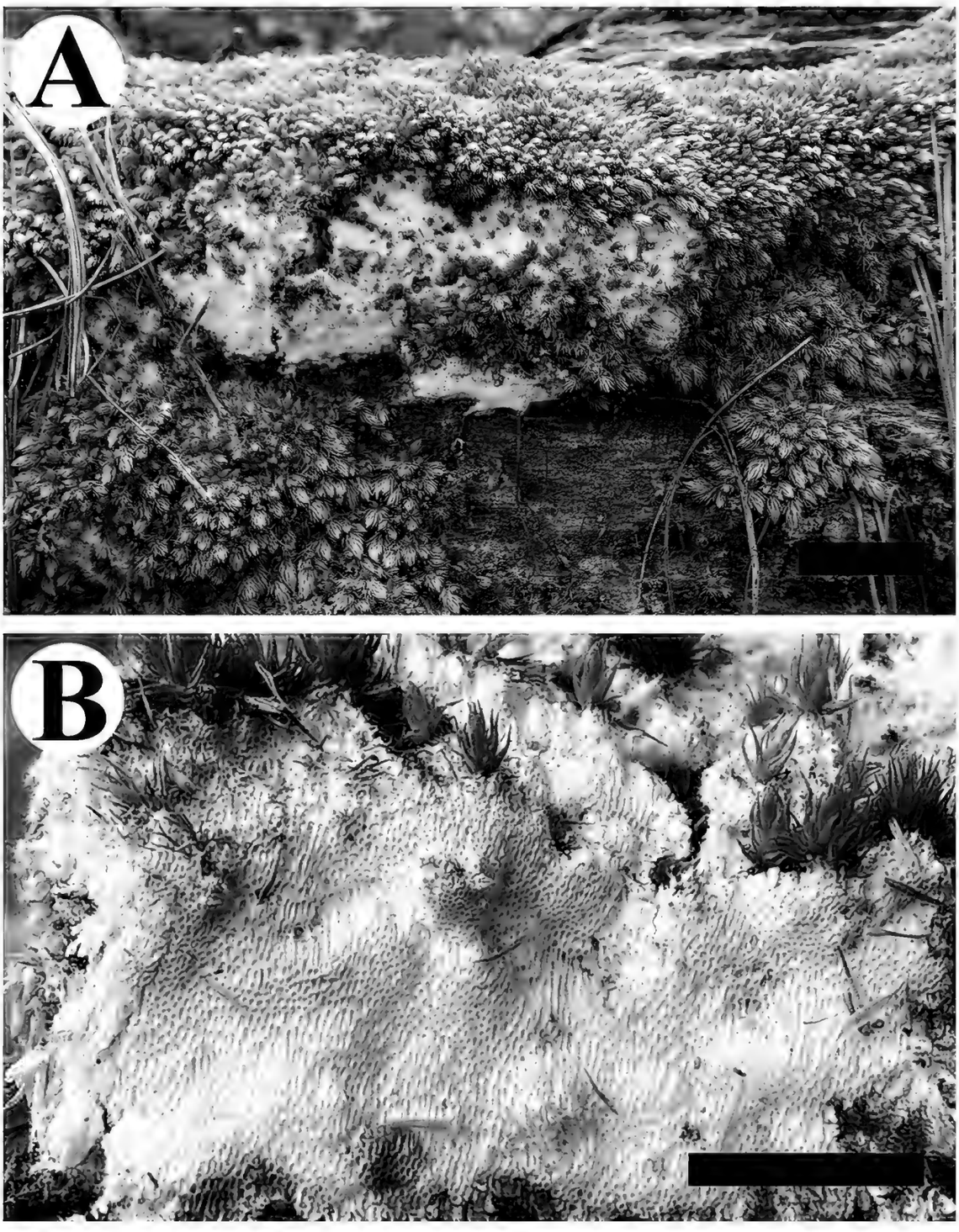


Fig. 2. *Cinereomyces wuliangshanensis* (holotype, SWFC 003405). Basidiomata. Scale bars: A = 2 cm; B = 0.5 mm.

The phylogenetic analysis of the nrDNA ITS region by Miettinen & Rajchenberg (2012) grouped *Cinereomyces* closely with three related genera—*Obba, Sebipora*, and *Gelatoporia*. Our current phylogeny strongly (100% BS,

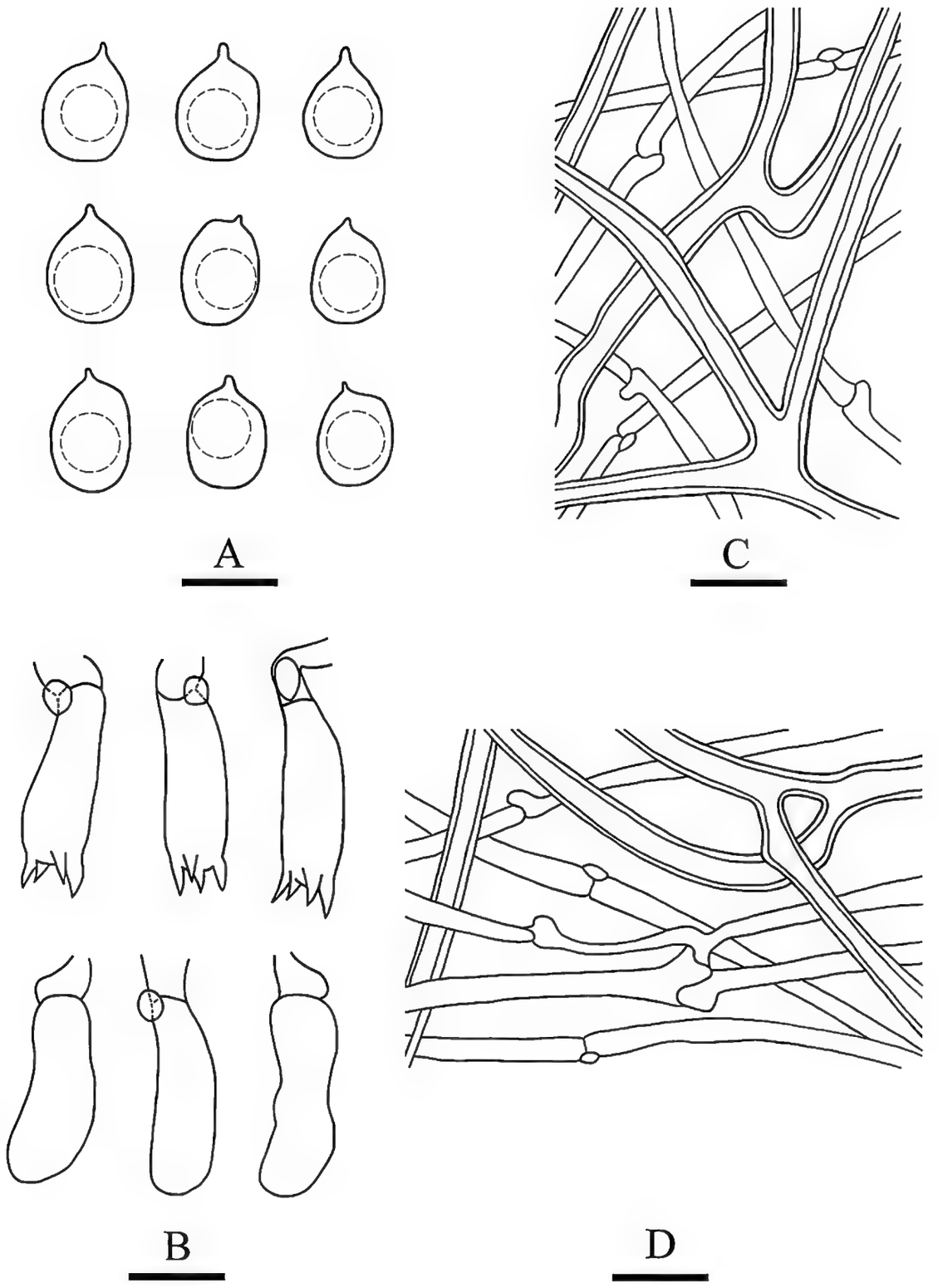


Fig. 3. *Cinereomyces wuliangshanensis* (holotype, SWFC 003405).
A. Basidiospores; B. Basidia and basidioles; C. Hyphae from trama;
D. Hyphae from subiculum. Scale bars: A = 5 *μm;* B–D = 10 μm.

100% BT, 1 BPP) supports the new taxon in a monophyletic lineage that groups with *C. lindbladii* and a clade comprising two species, *Obba rivulosa* and *O. valdiviana*.

Morphologically, *C. lindbladii* can be distinguished from *C. wuliangshanensis* by its greyish pore surface and larger basidiospores (5–7 × 1.5–2 µm; Ryvarden & Melo 2014); *O. rivulosa* differs from *C. wuliangshanensis* by a monomitic hyphal system and thin to slightly thick-walled and wider basidiospores (4.6–5.2 × 3.7–4.3; Miettinen & Rajchenberg 2012); *O. valdiviana,* also distinguished by its monomitic hyphal system, is further distinguished by its cyanophilous and wider basidiospores (4.6–5.3 × 4.2–5.0; Miettinen & Rajchenberg 2012).

Cinereomyces dilutabilis (Log.-Leite & J.E. Wright) Miettinen shares a dimitic hyphal system with *C. wuliangshanensis*. However, *C. dilutabilis* is distinguished by its light brownish basidiomata with smaller (6–8 per mm) pores and narrower basidiospores (4.8–5.5 × 2.4–2.8; Miettinen 2012).

With respect to distribution, *Cinereomyces* species are a rarely studied group of *Basidiomycota* (Loguercio-Leite & Wright 1998, Núñez & Ryvarden 2001, Dai 2012, Ryvarden & Melo 2014). Previously, only one species of *Cinereomyces*, *C. lindbladii,* was recorded in China (Dai 2012). However, the diversity of *Cinereomyces* species in China is still not well known, especially in southern China. In addition to our new species, *C. wuliangshanensis,* other related *Cinereomyces* taxa have been described from this region (Zhao & Cui 2012, Liu & al. 2017, Zhao & al. 2017, Zhao & Ma 2019). There is still a lot of room to explore the diversity of *Cinereomyces* species in southern China.

Acknowledgements

Special thanks are due to Drs. Mei-Ling Han (Langfang Normal University, Hebei, P.R. China) and Sana Jabeen (University of Education, Lahore, Pakistan) for expert presubmission review. The research was supported by the National Natural Science Foundation of China (Project No. 32170004), Yunnan Fundamental Research Project (Grant No. 202001AS070043), the High-level Talents Program of Yunnan Province (YNQRQNRC-2018-111), Yunnan Key Laboratory of Plateau Wetland Conservation, Restoration and Ecological Services (202105AG070002), and Science and Technology Innovation Project of Southwest Forestry University (KY21017).

Literature cited

Binder M, Hibbett DS, Larsson KH, Larsson E, Langer E, Langer G. 2005. The phylogenetic distribution of resupinate forms across the major clades of mushroom-forming fungi (*Homobasidiomycetes*). Systematics and Biodiversity 3: 113–157. https://doi.org/10.1017/S1477200005001623

Binder M, Justo A, Riley R, Salamov A, Lopez-Giraldez F, Sjökvist E, Copeland A & al. 2013. Phylogenetic and phylogenomic overview of the *Polyporales*. Mycologia 105: 1350–1373. https://doi.org/10.3852/13-003

Dai YC. 2012. Polypore diversity in China with an annotated checklist of Chinese polypores. Mycoscience 53: 49–80. https://doi.org/10.1007/s10267-011-0134-3

Felsenstein J. 1985. Confidence intervals on phylogenetics: an approach using bootstrap. Evolution 39: 783–791. https://doi.org/10.1111/j.1558-5646.1985.tb00420.x

Hall TA. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids Symposium Series 41: 95–98.

Jülich W. 1982 ["1981"]. Higher taxa of *Basidiomycetes*. Bibliotheca Mycologica 85. 485 p.

Justo A, Miettinen O, Floudas D, Ortiz-Santana B, Sjökvist E, Lindner D, Nakasone K & al. 2017. A revised family-level classification of the *Polyporales* (*Basidiomycota*). Fungal Biology 121: 798–824. https://doi.org/10.1016/j.funbio.2017.05.010

Liu WL, Xu TM, Shen S, Liu XF, Sun Y, Zhao CL. 2017. *Perenniporia puerensis* sp. nov. from southern China. Mycotaxon 132: 867–874. https://doi.org/10.5248/132.867

Loguercio-Leite C, Wright JE. 1998. *Diplomitoporus dilutabilis*, a new species of *Polyporaceae* (*Aphyllophorales*) from Santa Catarina Island, Brazil. Mycotaxon 68: 47–52.

Miettinen O. 2012. *Diplomitoporus dilutabilis* belongs to *Cinereomyces* (*Polyporales, Basidiomycota*). Mycotaxon 121: 345–348. https://doi.org/10.5248/121.345

Miettinen O, Larsson KH. 2011. *Sidera*, a new genus in *Hymenochaetales* with poroid and hydnoid species. Mycological Progress 10: 131–141.

https://doi.org/10.1007/s11557-010-0682-5

Miettinen O, Rajchenberg M. 2012. *Obba* and *Sebipora*, new polypore genera related to *Cinereomyces* and *Gelatoporia* (*Polyporales, Basidiomycota*). Mycological Progress 11: 131–147. https://doi.org/10.1007/s11557-010-0736-8

Miller MA, Holder MT, Vos R, Midford PE, Liebowitz T, Chan L, Hoover P, Warnow T. 2009. The CIPRES Portals. CIPRES. http://www.phylo.org/sub_sections/portal. 2009-08-04. (Archived by WebCite at http://www.webcitation.org/5imQlJeQa).

Núñez M, Ryvarden L. 2001. East Asian polypores 2. *Polyporaceae* s. lato. Synopsis Fungorum 14: 165–522.

Nylander JAA. 2004. MrModeltest v2. Program distributed by the author. Evolutionary Biology Centre, Uppsala University.

Petersen JH. 1996. Farvekort. The Danish Mycological Society's colour-chart. Foreningen til Svampekundskabens Fremme, Greve.

Ronquist F, Huelsenbeck JP. 2003. MrBayes 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19: 1572–1574. https://doi.org/10.1093/bioinformatics/btg180

Ryvarden L, Melo I. 2014. Poroid fungi of Europe. Synopsis Fungorum 31. 455 p.

Swofford DL. 2002. PAUP*: phylogenetic analysis using parsimony (*and other methods). Version 4.0b10. Sinauer Associates, Massachusetts.

Tomšovský M, Menkis A, Vasaitis R. 2010. Phylogenetic relationships in European *Ceriporiopsis* species inferred from nuclear and mitochondrial ribosomal DNA sequences. Fungal Biology 114: 350–358. https://doi.org/10.1016/j.funbio.2010.02.004

White TJ, Bruns T, Lee S, Taylor J. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. 315–322, in: MA Innis & al. (eds). PCR protocols: a guide to methods and applications. Academic Press, San Diego. https://doi.org/10.1016/B978-0-12-372180-8.50042-1

Zhao CL, Cui BK. 2012. A new species of *Grammothelopsis* (*Polyporales*, *Basidiomycota*) described from southern China. Mycotaxon 121: 291–296. https://doi.org/10.5248/121.291

Zhao CL, Ma X. 2019. *Perenniporia mopanshanensis* sp. nov. from China. Mycotaxon 134: 125–137. https://doi.org/10.5248/134.125

Zhao CL, Wu ZQ. 2017. *Ceriporiopsis kunmingensis* sp. nov. (*Polyporales*, *Basidiomycota*) evidenced by morphological characters and phylogenetic analysis. Mycological Progress 16: 93–100. https://doi.org/10.1007/s11557-016-1259-8

Zhao CL, Liu SL, Ren GJ, Ji XH, He SH. 2017. Three species of wood-decaying fungi in *Polyporales* new to China. Mycotaxon 132: 29–42. https://doi.org/10.5248/132.29

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 221–226

https://doi.org/10.5248/137.221

Gangliostilbe wuzhishanensis sp. nov. from Hainan, China

Rong-Yu Liu, Zhao-Xue Zhang, Tai-Chang Mu,
Shu-Bin Liu, Xiu-Guo Zhang, Ji-Wen Xia*

Shandong Provincial Key Laboratory for Biology of Vegetable Diseases and Insect Pests, College of Plant Protection, Shandong Agricultural University, Taian, Shandong 271018, China

* Correspondence to: *xiajiwen1@126.com; xiajiwen163@163.com*

Abstract—*Gangliostilbe wuzhishanensis* is described and illustrated as a new species from dead branches of an unidentified broadleaf tree in Hainan Province, China. The fungus is characterized by synnematous conidiophores with monoblastic conidiogenous cells producing 3–6-euseptate, 22–30 × 5–7 µm, clavate conidia. A key to *Gangliostilbe* species is provided.

Key words—anamorphic fungi, conidial fungi, hyphomycetes, taxonomy

Introduction

Gangliostilbe was erected by Subramanian & Vittal (Vittal 1976) with *G. indica* Subram. & Vittal as the type species. It is characterized by synnematous and unbranched conidiophores with integrated, determinate, monoblastic conidiogenous cells that produce solitary, obovoid, ovoid or fusiform, euseptate conidia. Four further species have been added to the genus: *G. costaricensis* Mercado & al., *G. malabarica* Subram. & Bhat, *G. verrucosa* Bhat & B. Sutton, and *G. yunnanensis* L.G. Ma & X.G. Zhang (Bhat & Sutton 1985, Subramanian & Bhat 1989, Mercado-Sierra & al. 1997, Ma & al. 2014).

Hainan Province (18.17°–20.17°N 108.62°–111.08°E) is an island in southern China. The annual mean temperature is 22–27 °C, and the

annual precipitation 100–260 cm. Wuzhishan National Nature Reserve, in central Hainan, has a typical tropical rainforest climate. Among our fungal collections from this region, we found a hyphomycetous fungus that conformed with *Gangliostilbe* Subram. & Vittal and is described and illustrated here as a new species, *G. wuzhishanensis*.

Materials & methods

Samples of dead branches were collected from Wuzhishan National Nature Reserve of Hainan Province, China, and taken to the laboratory in zip-lock plastic bags. Samples were processed and examined following the methods described in Ma & al. (2011). Micromorphological characters were observed using an Olympus SZX10 stereomicroscope and Olympus BX53 microscope, both fitted with Olympus DP80 high definition colour digital cameras to photo-document fungal structures. Conidia were measured at their widest point. The range between minimum and maximum values for microscopic measurements is given. Adobe Photoshop CS5 was used for image processing to assemble photographs into plates. Single spore isolations did not grow on PDA at 25 °C after several attempts and therefore only morphological data are used here. The studied specimens are deposited in the Herbarium of Plant Pathology, Shandong Agricultural University, Taian, China (HSAUP).

Taxonomy

Gangliostilbe wuzhishanensis J.W. Xia, R.Y. Liu & X.G. Zhang, **sp. nov.** Fig. 1

MB 843815

Differs from other *Gangliostilbe* species by its clavate conidia.

Type: China, Hainan Province, Wuzhishan National Nature Reserve, on dead stems of an unidentified broadleaf tree, 20 May 2021, R.Y. Liu (**Holotype**, HSAUP WZ2401).

Etymology: in reference to the type locality.

Colonies on natural substrate effuse, dark brown. Mycelium mostly immersed, partly superficial, composed of branched, septate, pale brown, smooth hyphae, 1–2.5 µm diam. Synnemata unbranched, erect, with dark brown stalks, consisting of parallel conidiophores, terminating in brown fertile heads, 200–270 µm long, 20–30 µm diam. at the middle, 30–50 µm diam. at the base. Conidiophores macronematous, synnematous, erect, unbranched, cylindrical, brown, thick-walled, multiseptate, smooth, divergent towards the distal part of the synnema, 1.5–2.5 µm diam. Conidiogenous cells monoblastic, integrated, terminal, determinate or percurrently extending, cylindrical, smooth, brown, thick-walled. Conidia solitary, acrogenous, clavate, brown, basal cells pale brown, smooth, thick-walled, 3–6-euseptate, 22–30 × 5–7 µm, 2–3 µm diam. at the truncate base.

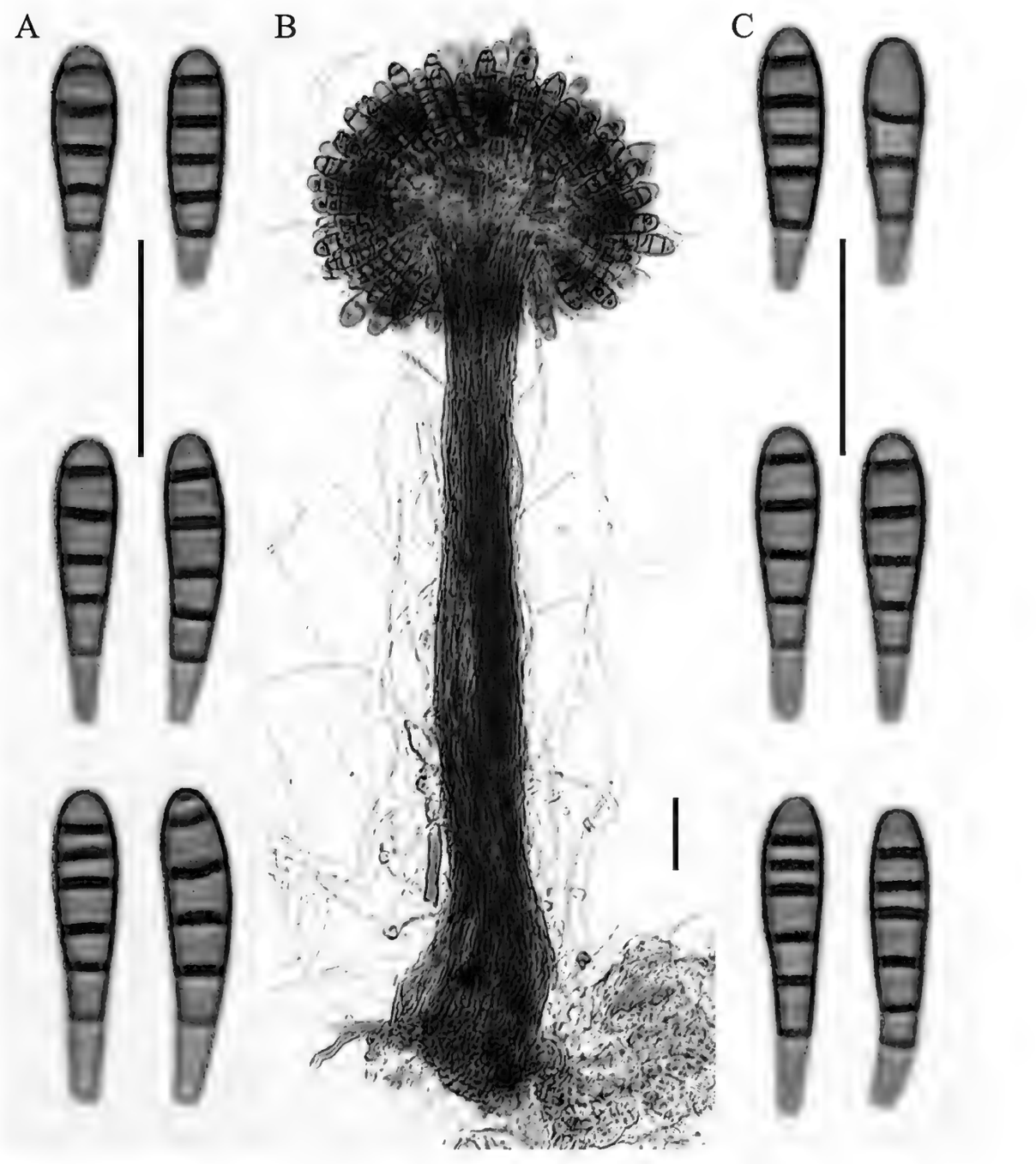


Fig. 1. *Gangliostilbe wuzhishanensis* (holotype, HSAUP WZ2401).
A, C. Conidia; B. Synnematous conidiophores with monoblastic conidia. Scale bars = 20 µm.

Comments – Conidial characters have been used to distinguish species within *Gangliostilbe*. *Gangliostilbe wuzhishanensis* is clearly distinguished from the other *Gangliostilbe* species by their different conidia: *G. indica* and *G. yunnanensis* produce obovoid to ellipsoidal conidia (Vittal 1976,

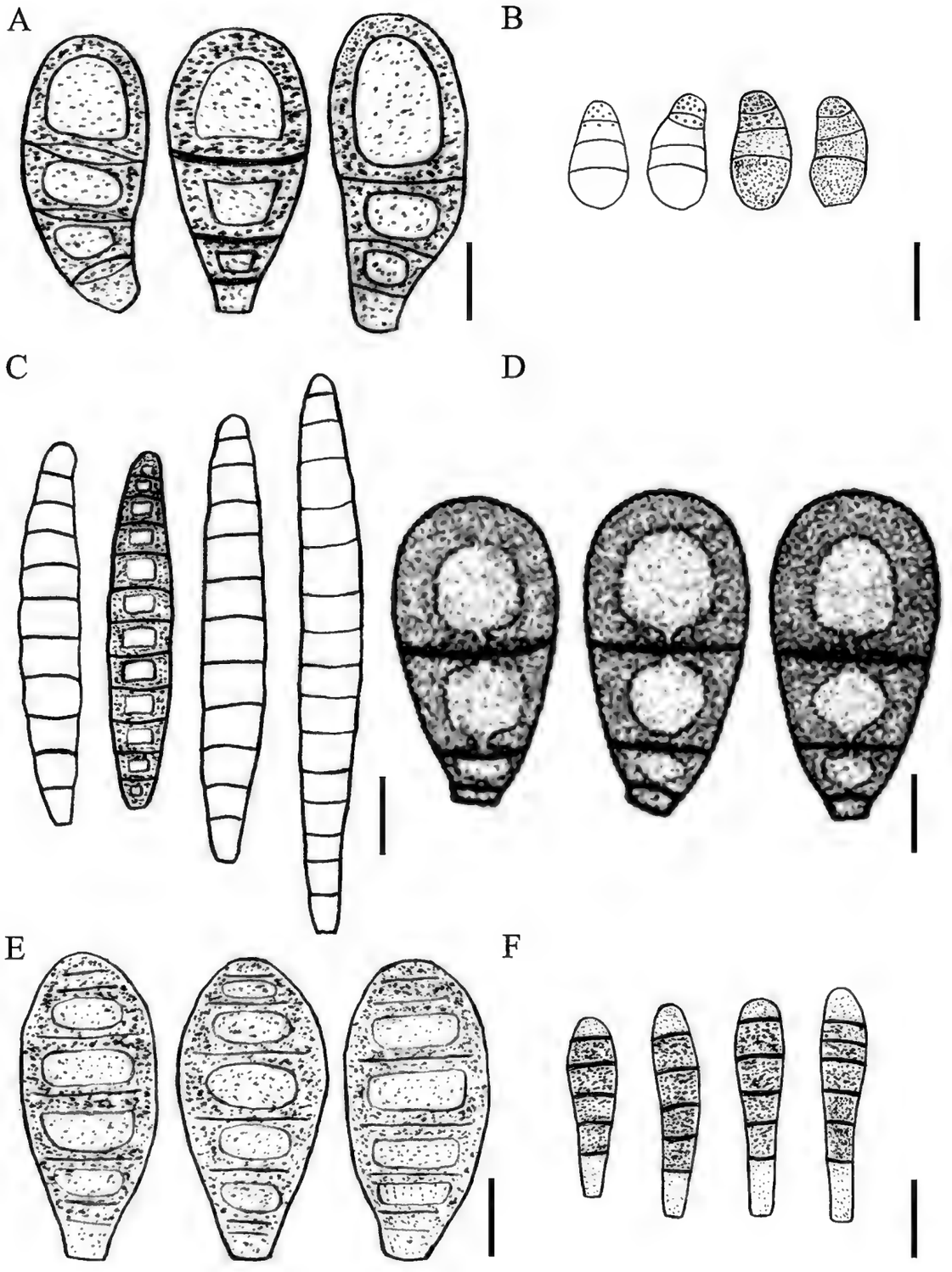


Fig. 2. *Gangliostilbe* spp.: representative conidia (re-drawn from the literature). A. ***G. indica*** (Vittal 1976); B. ***G. verrucosa*** (Bhat & Sutton 1985); C. ***G. malabarica*** (Subramanian & Bhat 1989); D. ***G. costaricensis*** (Mercado-Sierra & al. 1997); E. ***G. yunnanensis*** (Ma & al. 2014); F. ***G. wuzhishanensis*** (this work). Scale bars = 10 μm.

Ma & al. 2014); *G. costaricensis* produces broadly obovoid conidia (Mercado-Sierra & al. 1997); *G. malabarica* produces elongated fusiform conidia (Subramanian & Bhat 1989); *G. verrucosa* produces ovoid to obclavate conidia (Bhat & Sutton 1985, Ma & al. 2014). Comparisons of conidial shapes from all *Gangliostilbe* species are shown in Fig. 2.

Key to species of *Gangliostilbe*

1. Conidia obovoid to ellipsoidal 2
1. Conidia not as above 3
2. Conidia broadly obovoid, uniformly pigmented, 38–48 × 20–25 µm, 3-septate; conidiophores 5–7 µm wide ..... *G. costaricensis*
2. Conidial cells unevenly pigmented; conidiophores ≤5 µm wide 4
3. Conidia ovoid to obclavate, 12.5–16 × 4.5–7.5 µm, 2–3(–4)-septate, dark brown, apical and subapical cells pale brown and verruculose; conidiophores unbranched ..... *G. verrucosa*
3. Conidia fusiform or clavate 5
4. Conidia 26–42 × 12–15 µm, 3-septate; conidiophores 3–4.5 µm wide ..... *G. indica*
4. Conidia 30–42 × 15–20 µm, 6- or 7-septate; conidiophores 2.5–4.2 µm wide ..... *G. yunnanensis*
5. Conidia fusiform, gangliar, elongated, ≤17-septate, light brown, smooth, 27–72 × 7–10 µm; conidiophores branched ..... *G. malabarica*
5. Conidia clavate, brown, truncate at the base, basal cells pale brown, smooth, thick-walled, 3–6-euseptate, 22–30 × 5–7 µm; conidiophores unbranched ..... *G. wuzhishanensis*

Acknowledgments

The authors express gratitude to Dr. Jian Ma (College of Agronomy, Jiangxi Agricultural University, Nanchang, Jiangxi, China) and Dr. Li-Guo Ma (Institute of Plant Protection, Shandong Academy of Agricultural Sciences, Jinan, Shandong, China) for serving as pre-submission reviewers and to Dr. Shaun Pennycook for nomenclatural review and Dr. Lorelei L. Norvell for editorial review. This work was jointly supported by the National Natural Science Foundation of China (Nos. 31900014, 31750001).

Literature cited

Bhat DJ, Sutton BC. 1985. New and interesting hyphomycetes from Ethiopia. Transactions of the British Mycological Society 85: 107–122. https://doi.org/10.1016/S0007-1536(85)80160-1

Ma J, Wang Y, O'Neill NR, Zhang XG. 2011. A revision of the genus *Lomaantha*, with the description of a new species. Mycologia 103(2): 407–410. https://doi.org/10.3852/10-176

Ma LG, Xia JW, Ma YR, Castañeda-Ruíz RF, Zhang XG. 2014. Two new species of *Spadicoides* and *Gangliostilbe* from southern China. Mycological Progress 13: 547–552. https://doi.org/10.1007/s11557-013-0937-z

Mercado-Sierra A, Gené J, Guarro J. 1997. Some Costa Rican hyphomycetes. I. Nova Hedwigia 64: 455–465. https://doi.org/10.1127/nova.hedwigia/64/1997/455

Subramanian CV, Bhat DJ. 1989 ["1987"]. Hyphomycetes from south India I. Some new taxa. Kavaka 15: 41–74.

Vittal BPR. 1976 ["1975"]. *Gangliostilbe indica*, a new synnematous hyphomycete from India. Kavaka 3: 69–71.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 227–237

https://doi.org/10.5248/137.227

Vesiculophora diversiseptata gen. & sp. nov. and *Anapleurothecium clavatum* & *Podosporium simile* spp. nov. from the Brazilian Amazon

Josiane Santana Monteiro[1,2*], Helen Maria Pontes Sotão[2], Miriely Cristina dos Santos Ferreira[2], Felipe de Jesus Rodrigues[3], William Kalhy Silva Xavier[3], De-Wei Li[4], Rafael Felipe Castañeda-Ruiz[5]

[1] *Instituto Tecnológico Vale, Rua Boaventura da Silva, 955, Nazaré, 66055-090, Belém, Brazil*

[2] *Museu Paraense Emílio Goeldi, Coordenação de Botânica, Av. Perimetral, 1901, Terra Firme, 66077-830, Belém, Brazil*

[3] *Universidade do Estado do Amapá, Av. Pres. Vargas, 650, Central, 68900-070, Macapá, Brazil*

[4] *The Connecticut Agricultural Experiment Station, Valley Laboratory, 153 Cook Hill Road, Windsor, CT 06095, USA*

[5] *Instituto de Investigaciones Fundamentales en Agricultura Tropical 'Alejandro de Humboldt'(INIFAT), Académico Titular de la Academia de Ciencias de Cuba, Calle 1 Esq. 2, Santiago de Las Vegas, C. Habana, Cuba, C.P. 17200*

* Correspondence to: *kiotobelbio2003@yahoo.com.br*

Abstract—Three asexual fungi are described and illustrated from the Brazilian Amazon: *Vesiculophora diversiseptata* as a new genus and species; and *Anapleurothecium clavatum* and *Podosporium simile* as new species. *Vesiculophora diversiseptata* is characterized by its conidiophores becoming scorpioid after successive subacroauxic extensions and monoblastic conidiogenous cells that produce heteroseptate, brown phragmoconidia; *A. clavatum* is distinguished by its ellipsoidal to clavate, 3-euseptate, brown conidia; and *P. simile* is characterized by its synnematous conidiomata with monotretic conidiogenous cells and brown, 3–11-eusepatate, mainly obclavate, verrucose conidia. Additionally, *Pleurothecium leptospermi* is transferred to *Anapleurothecium*.

Key words—hyphomycetes, saprobes, taxonomy, tropical fungi

Introduction

The fungal diversity in the Brazilian Amazon remains underestimated, especially for microfungi. Taxonomic studies are scarce and concentrated in a few areas of this biome (Hernández-Gutiérrez 2013, Barbosa & al. 2017, Monteiro & al. 2018, 2019). However, mycological surveys in Amazon conservation units continue to contribute to an increasing number of recorded species (Barbosa & al. 2017, Monteiro & al. 2017, 2019), while collections in urbanized areas have also revealed many additions to Brazilian fungi in recent years (Monteiro & al. 2017, Santos & al. 2018, Barbosa & al. 2021).

During our ongoing mycological surveys of conidial fungi on decaying leaf litter from the Brazilian Amazon forest, we collected three interesting species. The conidiogenesis and conidial features clearly place two of these fungi in *Anapleurothecium* (Hernández-Restrepo & al. 2017) and *Podosporium* (Wang & al. 2016), while the third is proposed as a new genus, *Vesiculophora diversiseptata*. All specimens are distinct from previously described taxa and are described here as new.

Materials & methods

Collections were made in Serra do Navio (Serra do Navio, Amapá state) (0.9121°S 51.9958°W), Floresta Nacional de Caxiuanã (Melgaço, Pará state) (1.7083°S 51.5292°W), and Campus de Pesquisa do Museu Paraense Emílio Goeldi (Belém, Pará state) (1.4511°S 48.4444°W). Samples of decaying leaf litter were placed in paper bags and taken to the laboratory at Museu Paraense Emílio Goeldi for processing following procedures outlined by Castañeda-Ruiz & al. (2016). Semipermanent and permanent slides were prepared in PVL resin (polyvinyl alcohol, lactic acid, and phenol) and lactoglycerol (lactic acid and glycerol). Reproductive structures were measured at a magnification of ×1000 and photographed using a Leica DM6 B microscope equipped with a digital camera. The holotypes and additional materials were deposited in the Herbario João Murça Pires (MG), Belém, Pará, Brazil. Several attempts to isolate these species onto agar media were unsuccessful.

Taxonomy

Vesiculophora J.S. Monteiro & R.F. Castañeda, **gen. nov.**

IF 558008

Differs from anamorphic *Ascotricha* by its conidiophores with unilateral extensions and its phragmosporous conidia; and from *Sporidesmiella* by its conidiophores with unilateral extensions just below the apical vesicles and its monoblastic conidiogenous cells.

Type species: *Vesiculophora diversiseptata* J.S. Monteiro & R.F. Castañeda

Etymology: Latin *Vesiculophora*, referring to the presence of vesicles on the conidiophores.

Colonies on the natural substratum effuse, brown or dark brown. Mycelium partly superficial and partly immersed. Conidiophores macronematous, mononematous, branched, with unilateral and apical vesicles, septate, smooth, brown or dark brown. Conidiogenous cells monoblastic, integrated, mostly intercalary, determinate, cylindrical, conidiogenous loci flattened. Conidial secession schizolytic. Conidia solitary, pleurogenous, obovoid, ellipsoidal or clavate, brown, dark brown near the base, phragmosporous, heteroseptate, 1-euseptate at base, distoseptate at the rest of body.

Vesiculophora diversiseptata J.S. Monteiro & R.F. Castañeda, **sp. nov.** Fig. 1

IF 558009

Differs from anamorphic *Ascotricha* spp. by its conidiophores with unilateral scorpioid extensions and its heteroseptate conidia; and from *Sporidesmiella* spp. by its conidiophores with scorpioid, unilateral sympodial extensions just below the apical vesicles and its monoblastic conidiogenous cells.

Type: Brazil, Pará, Melgaço, Floresta Nacional de Caxiuanã, Estação Científica Ferreira Penna, Parcel B ESECAFLOR, on decaying wood of an unidentified dicotyledonous plant, 16.XI.2019, coll. J.S. Monteiro (**Holotype**, MG 237208).

Etymology: Latin, *diversi-*, meaning in different ways, diverse, contrary; *septata*, referring to the septa.

Saprobic on decaying wood. Colonies on the natural substratum effuse, hairy, scattered, brown or dark brown. Mycelium partly superficial and partly immersed. Hyphae branched, septate, smooth, pale brown, 2–2.5 µm wide. Conidiophores macronematous, mononematous, erect, straight or slightly flexuous, cylindrical toward the base, unilateral, scorpioid branched toward the apex, with 1–4-vesicles; vesicles conical, rounded at the tip, 3–4 × 3–4 µm, produced after successive subacroauxic lateral extensions combined with enteroblastic percurrent regenerations; 7–9-septate, smooth, brown or dark brown at the base, paler toward the apex, 180–240 × 5.5–6 µm. Conidiogenous cells monoblastic, integrated, cylindrical, becoming mostly intercalary after successive subacroauxic lateral and enteroblastic percurrent regenerations of the conidiophores, smooth, mid brown, 15–18.5(–29) × 4.5–6 µm. Conidiogenous loci flattened, pale brown. Conidial secession schizolytic. Conidia solitary, pleurogenous, broad obovoid, ellipsoidal or clavate, smooth, golden brown to brown, 31.5–39 × 11–14.5 µm (av.= 36.5 × 12.7 µm, n = 25), brown, basal cell conical, slightly darker than other conidial cells, rounded at the apex, phragmosporous, heteroseptate,

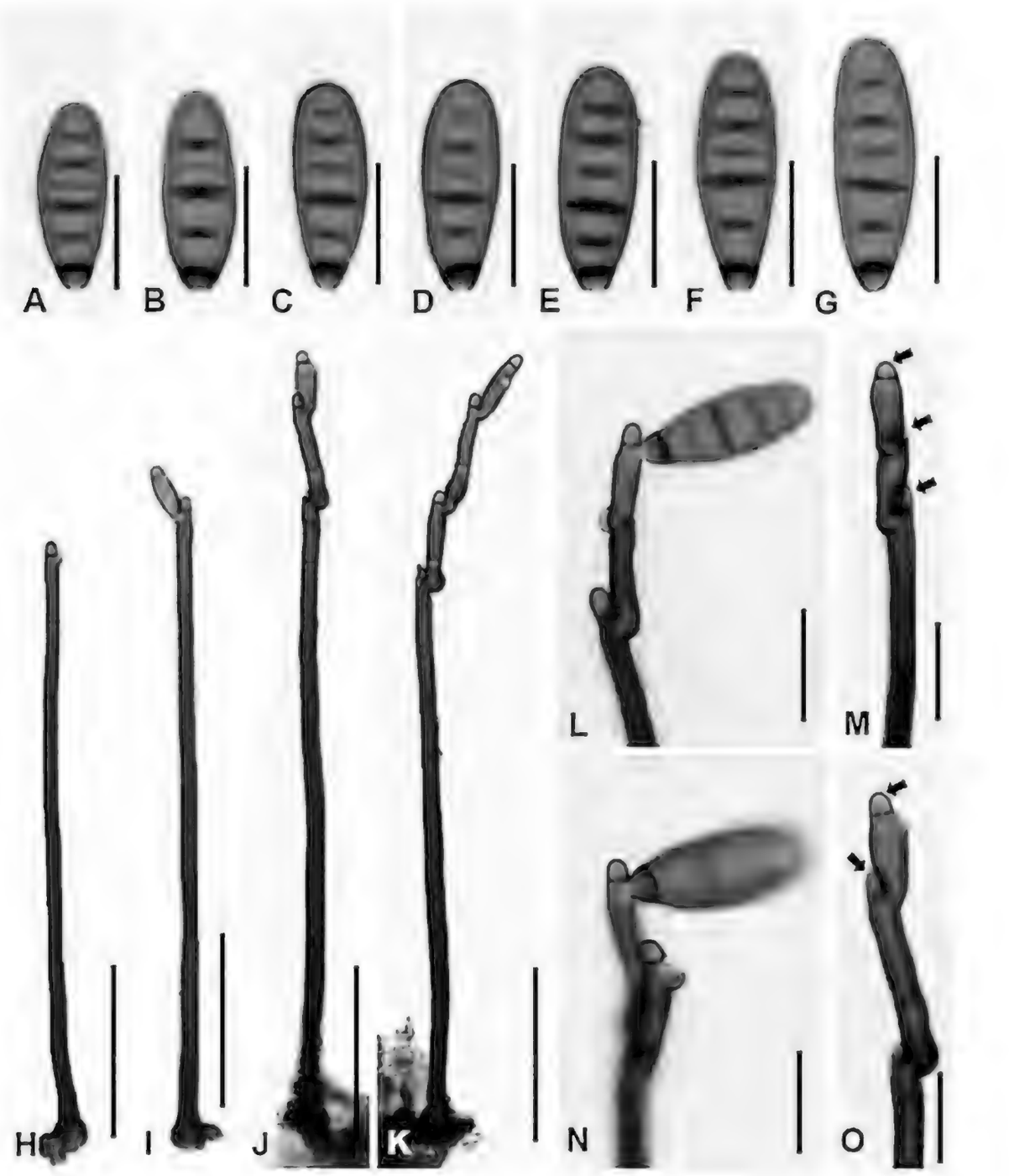


Fig. 1. *Vesiculophora diversiseptata* (holotype, MG 237208). A–G. Conidia; H–K. Conidiophores; L, N. Conidia and conidiogenous cells; M, O. Conidiogenous cells and apical vesicles. Scale bars: A–G, L–O = 20 µm; H–K = 50 µm.

1-euseptate at base, (3–)5(–6)-distoseptate toward the apex. Sexual morph undetermined.

Comments—*Vesiculophora* morphologically resembles anamorphic *Ascotricha* Berk. species (Berkeley 1838, Li & Zhao 2018) because of its unilateral branched

conidiophores and presence of vesiculate extensions. However, *Ascotricha* species have polyblastic, sympodial, denticulate conidiogenous cells and amerosporous conidia with rhexolytic or schizolytic conidial secession (Seifert & al. 2011, Li & Zhao 2018). *Ascotricha rugispora* (Okane & al.) D.W. Li & G.H. Zhao resembles *Vesiculophora* in the presence of vesicles on conidiophores but is distinguished by the short, clavate, hyaline remaining branches and polyblastic, discrete, curved conidiogenous cells with conspicuous scars that produce rugose, amerosporous conidia (Okane & al. 2001, Seifert & al. 2011). *Sporidesmiella* P.M. Kirk, which has distoseptate conidia similar to *Vesiculophora*, is distinguished by terminal, indeterminate conidiogenous cells with enteroblastic percurrent extensions (Kirk 1982, Ma & al. 2012).

Vesiculophora has a particular growth of conidiophores with subacroauxic lateral extensions and monoblastic conidial production combined with the enteroblastic percurrent regenerations in the conidiogenous loci, after conidial secession, these features separate it from other hyphomycetous genera described in Seifert & al. (2011).

Anapleurothecium clavatum J.S. Monteiro & R.F. Castañeda, **sp. nov.** FIG. 2

IF 557977

Differs from *Anapleurothecium botulisporum* by its clavate to ellipsoidal and longer conidia.

TYPE: Brazil, Amapá, Serra do Navio, Serra do Navio, Mirante da serra, Mina desativada C3, on decaying wood of an unidentified dicotyledonous plant, 10.I.2017, coll. F.J. Rodrigues & W.K.S. Xavier (**Holotype**, MG 228012).

ETYMOLOGY: Latin, *clavatum*, referring to the clavate conidial shape.

SAPROBIC on decaying wood. COLONIES on the natural substratum effuse, hairy, scattered, brown. MYCELIUM superficial and immersed, hyphae branched, septate, smooth, pale brown, 2–2.5 µm wide. CONIDIOPHORES macronematous, mononematous, erect, straight or slightly flexuous, cylindrical, unbranched, 2–6-septate, smooth, brown at the base, paler toward the apex, 43–75 × 4–6 µm. CONIDIOGENOUS CELLS polyblastic, integrated, terminal or intercalary, sympodial, cylindrical, denticulate, smooth, mid brown, 18–32 × 3–4 µm; denticles conspicuous, cylindrical, truncate at the apex, 2.5–4 × 1–1.5 µm. Conidial secession schizolytic. CONIDIA solitary, acropleurogenous, 3-euseptate, ellipsoidal to clavate, straight or slightly curved, rounded at the apex, smooth, brown, 20–26.5 × 6–7 µm (av. = 23.1 × 6.2 µm, n = 20), often with basal cell conical, pale brown, 4–4.5 µm wide. SEXUAL MORPH undetermined.

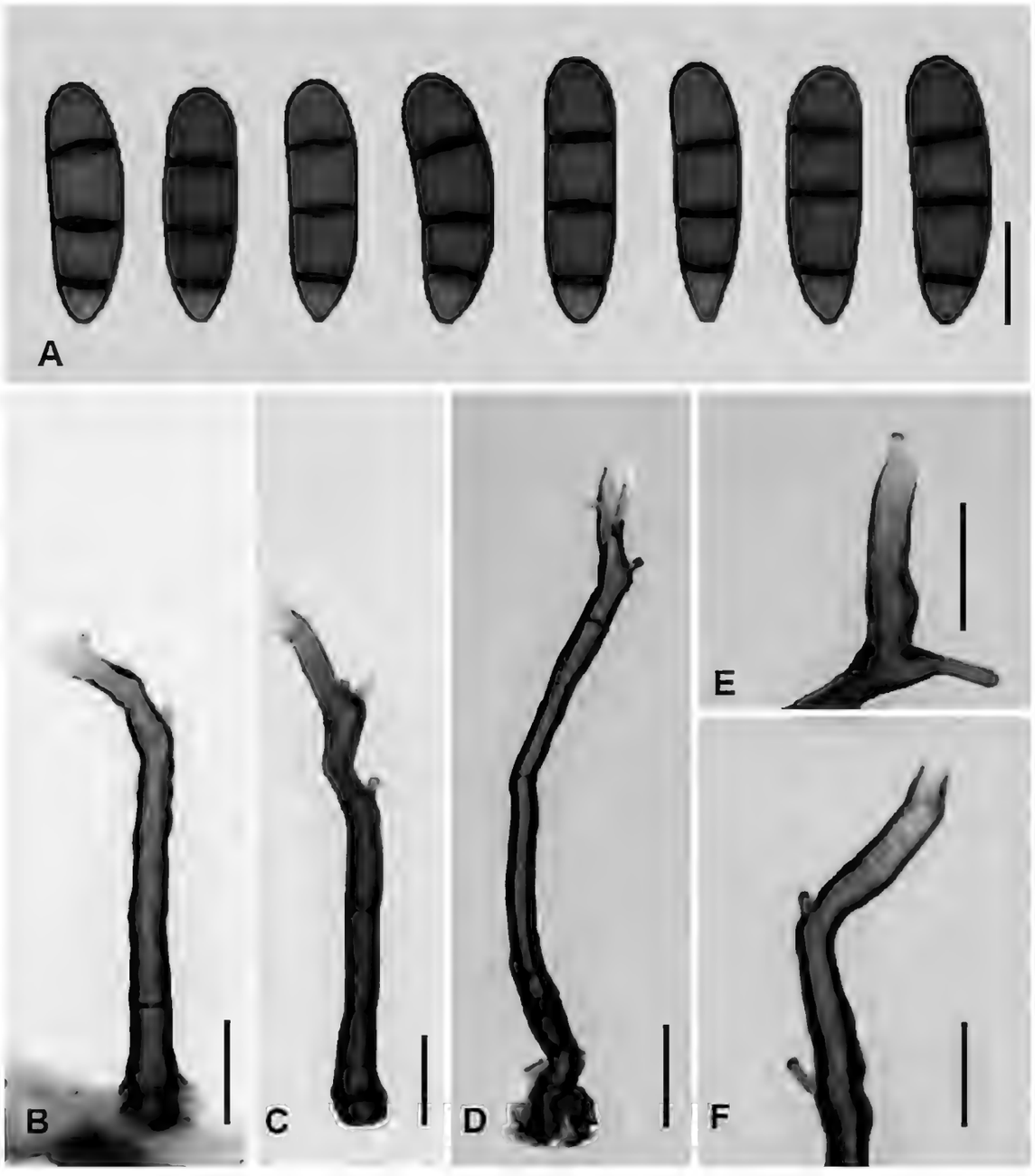


Fig. 2. *Anapleurothecium clavatum* (holotype, MG 228012). A. Conidia; B–D. Conidiophores; E–F. Conidiogenous cells. Scale bars: 10 μm.

Comments—*Anapleurothecium* Hern.-Restr. & al. was proposed by Hernández-Restrepo & al. (2017) with *A. botulisporum* Hern.-Restr. & al. as its type species. It is characterized by macronematous, mononematous conidiophores with polyblastic, sympodial, denticulate conidiogenous cells that produce 3-euseptate, smooth, brown conidia with pale brown basal cells (Hernández-Restrepo & al. 2017, Qiu & al. 2020). The type species is distinguished from *A. clavatum* by longer conidiophores (74–185 × 5–6 μm) and conidiogenous

cells (10–47 × 4–7 µm). Furthermore, *A. clavatum* has ellipsoidal to clavate conidia, while in *A. botulisporum* the conidia are botuliform to cylindrical and shorter (15–21 × 6–8.5 µm).

Pleurothecium leptospermi has unbranched conidiophores, with denticulate conidiogenous cells producing fusiform, 3-euseptate, versicolored, darkly pigmented conidia measuring 15–18 × 4–5 µm (Cooper 2005). Although lacking typical recurved conidiogenous cells, *P. leptospermi* was originally assigned to *Pleurothecium* Höhn., but the species is clearly congeneric with *Anapleurothecium*, and is proposed here as a new combination.

Anapleurothecium leptospermi (J.A. Cooper) J.S. Monteiro & R.F. Castañeda, **comb. nov.**

IF 557979

≡ *Pleurothecium leptospermi* J.A. Cooper, New Zealand Journal of Botany 43(1): 334 (2005).

Key to *Anapleurothecium* species

1. Conidia with basal and apical cells pale brown, fusiform to slightly clavate, 15–18 × 4–5 µm ..... *A. leptospermi*
1. Conidia with only basal cell pale brown, other shapes 2
2. Conidia botuliform to cylindrical, 15–21 × 6–8.5 µm ..... *A. botulisporum*
2. Conidia ellipsoidal to clavate, 20–26.5 × 5–7 µm ..... *A. clavatum*

Podosporium simile J.S. Monteiro & R.F. Castañeda, **sp. nov.** Fig. 3

IF 557978

Differs from *Podosporium nilgirense* by its rostrate, 3–11-euseptate, longer conidia.

Type: Brazil, Pará, Belém, Campus de Pesquisa do Museu Paraense Emílio Goeldi, secondary forest fragment next to the side of Building Botany Coordination, on decaying culm of *Bambusa* sp. (*Poaceae*), 07.VIII.2018, coll. J.S. Monteiro (**Holotype**, MG 237213).

Etymology: Latin, *simile*, referring to the morphological similarity to *Podosporium nilgirense*.

Saprobic on decaying bamboo culm. Colonies on the natural substratum effuse, scattered, brown to dark brown. Mycelium mostly immersed, composed of septate, smooth to roughened, pale brown to brown, branched hyphae. Conidiomata synnematal erect, straight or slightly flexuous, solitary or in groups of 2–3, simple, cylindrical, dark brown to black, 360–790 µm long, 30–65 µm at the base of the stalk, ≤110 µm wide at the apical region. Conidiophores macronematous, erect, septate, unbranched, cylindrical, verrucose, brown, 2–2.5 µm wide, diverging terminally. Conidiogenous

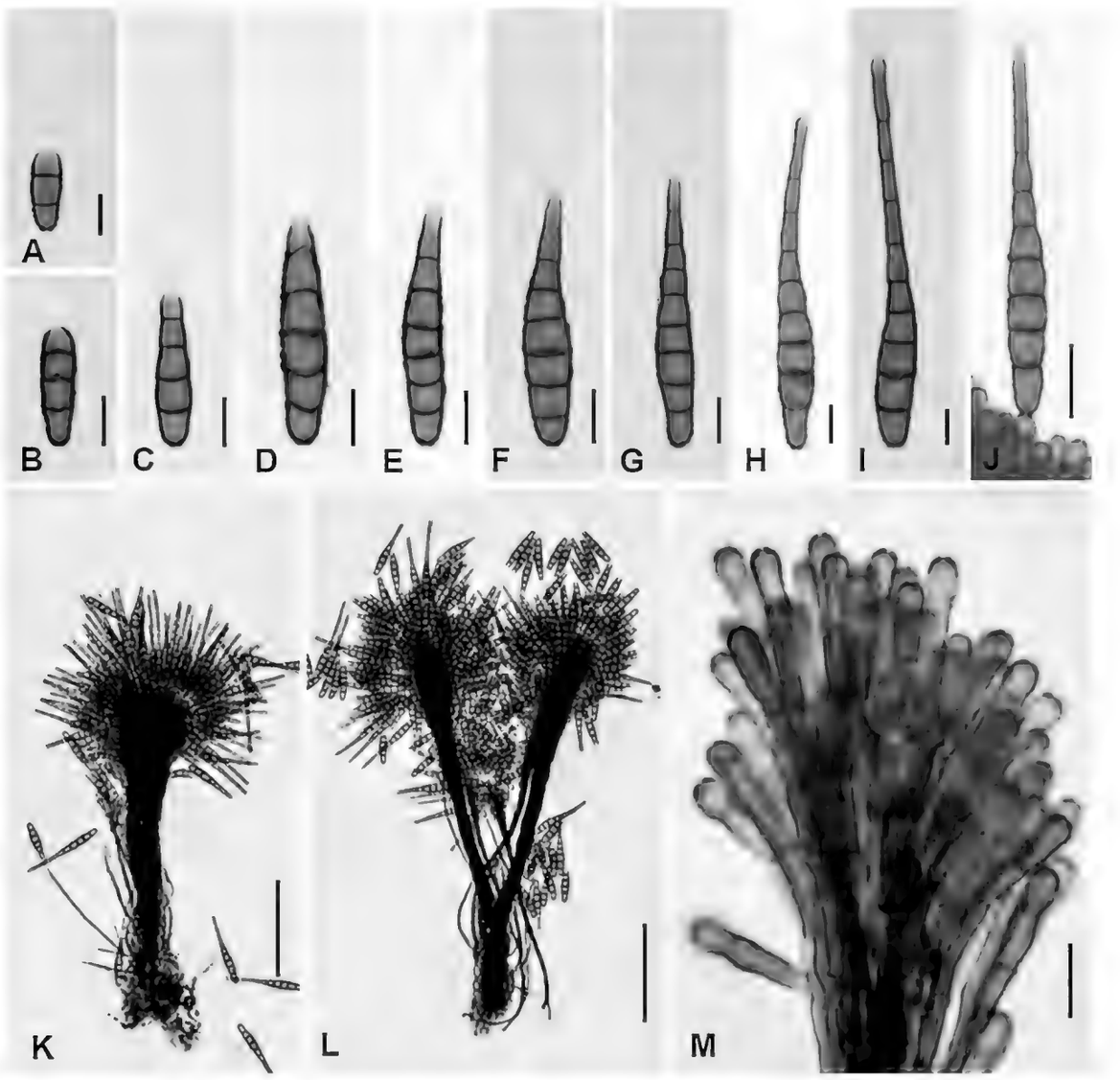


Fig. 3. *Podosporium simile* (holotype, MG 237213). A–I. Conidia; J. Conidiogenous cells and conidium; K–L. Synnemata; M. Details of conidiogenous cells. Scale bars: A–J, M = 10 µm, K–L = 100 µm.

cells enteroblastic, monotretic, integrated, terminal, determinate, cylindrical to clavate, verrucose, pale brown, 7.5–12.5 × 3.5–5 µm, with dark scar and conspicuous pore at the apex. Conidial secession schizolytic. Conidia acrogenous, solitary, obclavate, sometimes rostrate, straight, 3–11-euseptate, verrucose, brown, paler toward the apex, 25–100 × 6–9 µm (av. = 55 × 7.2 µm, n = 20); apical cell rounded, subhyaline to pale brown; basal cell truncate, with a depressed hilum, 2–2.5 µm wide. Sexual morph undetermined.

Comments—*Podosporium* Schwein. was established by Schweinitz (1832) and lectotypified with *P. rigidum* by Ellis (1971). The genus is characterized

by dark brown to black cylindrical synnemata, branched or unbranched conidiophores with monotretic, percurrent conidiogenous cells that produce acrogenous, multiseptate, obclavate, smooth or ornamented conidia (Ellis 1971, Zhang & al. 2011). Seifert & al. (2011) accepted only nine species in *Podosporium*: *P. bacilliforme* J.Y. Wang & al. (Wang & al. 2016), *P. cyclocaryae* Y.D. Zhang & X.G. Zhang (Zhang & al. 2011), *P. biseptatum* Joanne E. Taylor & al. (Taylor & Hyde 2003), *P. elongatum* J.L. Chen & Tzean (Chen & Tzean 1993), *P. duartei* Mercado (Mercado-Sierra 1983), *P. nilgirense* (Subram.) M.B. Ellis (Ellis 1976), *P. rigidum* Schwein. (Schweinitz 1832), *P. etheldoidgeae* Crous & al. (Crous & al. 1995), and *P. furcatum* R. Sharma & Panwar (Sharma & Panwar 1986). However, two of these species should be re-evaluated to confirm their affiliation with *Podosporium*: *P. etheldoidgeae* has polytretic, intercalary conidiogenous cells; *P. furcatum* has euseptate and distoseptate conidia.

Podosporium simile has obclavate conidia similar to *P. elongatum* and *P. nilgirense*. However, *P. elongatum* differs by its bigger (62–188 × 6–10 µm) conidia with 8–21-eusepta (Chen & Tzean 1993), and *P. nilgirense* differs by its smaller (32–50 × 7–9 µm) conidia with only 4–6 eusepta (Ellis 1976).

Acknowledgments

The authors express their sincere gratitude to Dr. E.H.C. McKenzie (Manaaki Whenua – Landcare Research, Auckland, New Zealand) and Dr. Jian Ma (College of Agronomy, Jiangxi Agricultural University, Nanchang, China) for their critical review of the manuscript. J.S. Monteiro thanks Programa de Capacitação Institucional — PCI/MPEG (CNPq Proc. 300646/2019–4) for financial support. M.C.S. Ferreira thanks CNPq for the PIBIC scholarship (Process 152710/2020-5). We are grateful to Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) and Universidade do Estado do Amapá (UEAP) for the infrastructure. Dr. Lorelei Norvell's editorial, and Dr. Shaun Pennycook's nomenclature reviews are greatly appreciated.

Literature cited

Barbosa FR, Gusmão LFP, Castaneda-Ruiz RF. 2017. *Craspedodidymella matogrossensis* gen. & sp. nov. from the Brazilian Amazon rainforest. Mycotaxon 132: 643–647. https://doi.org/10.5248/132.643

Barbosa FR, Fiuza PO, Monteiro JS, Silva AP, Gusmão LFP, Castañeda-Ruiz RF. 2021. *Parathozetella microsperma* gen. & sp. nov. from the Brazilian Amazon. Mycotaxon 136: 351–357. https://doi.org/10.5248/136.351

Berkeley MJ. 1838. Notices of British fungi [108–137]. Annals of Natural History 1: 257–264.

Castañeda-Ruiz RF, Heredia G, Gusmão LFP, Li DW. 2016. Fungal diversity of Central and South America. 197–217, in: DW Li (ed.). Biology of Microfungi. Springer International Publishing. https://doi.org/10.1007/978-3-319-29137-6_9

Chen JL, Tzean SS. 1993. *Podosporium elongatum* a new synnematous hyphomycete from Taiwan. Mycological Research 97: 637–640. https://doi.org/10.1016/S0953-7562(09)81190-8

Cooper JA. 2005. New Zealand hyphomycete fungi: additional records, new species and notes on interesting collections. New Zealand Journal of Botany 43: 323–349. https://doi.org/10.1080/0028825X.2005.9512957

Crous PW, Wingfield MJ, Kendrick WB. 1995. Foliicolous dematiaceous hyphomycetes from *Syzygium cordatum*. Canadian Journal of Botany 73: 224–234.

https://doi.org/10.1139/b95-025

Ellis MB. 1971. Dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew Surrey.

Ellis MB. 1976. More dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew Surrey.

Hernández-Gutiérrez AH. 2013. New or rare fungi from eastern Amazonia. 1. *Circinoconiopsis amazonica* gen. and sp. nov. Mycotaxon 123: 107–111. https://doi.org/10.5248/123.107

Hernández-Restrepo M, Gené J, Castañeda-Ruiz RF, Mena-Portales J, Crous W, Guarro J. 2017. Phylogeny of saprobic microfungi from Southern Europe. Studies in Mycology 86: 53–97. https://doi.org/10.1016/j.simyco.2017.05.002

Kirk PM. 1982. New or interesting microfungi VI. *Sporidesmiella* gen. nov. (hyphomycetes). Transactions of the British Mycological Society 79: 479–489.

https://doi.org/10.1016/S0007-1536(82)80040-5

Li D-W, Zhao G. 2018. *Ascotricha microspora* sp. nov. from Cayman Islands. Mycotaxon 133: 219–228. https://doi.org/10.5248/133.219

Ma J, Zhang YD, Ma LG, Castañeda-Ruíz RF, Zhang XG. 2012. Three new species of *Sporidesmiella* from southern China. Mycoscience 53: 187–193.

https://doi.org/10.1007/S10267-011-0152-1

Mercado-Sierra A. 1983. Nuevos e interesantes hifomicetes enteroblasticos de Cuba. Acta Botanica Cubana 16: 1–8.

Monteiro JS, Carmo LT, Sotão HMP. 2017. A new species of *Bhatia* (asexual ascomycetes) and new records from Brazil. Phytotaxa 331: 263–272.

https://doi.org/10.11646/phytotaxa.331.2.10

Monteiro JS, Sotão HMP, Cáceres MES, Lücking R, Hernández-Gutiérrez A. 2018. Checklist dos fungos da Floresta Nacional de Caxiuanã, Pará, Brasil. I. Fungos conidiais e liquenizados. Boletim do Museu Paraense Emílio Goeldi. Ciências Naturais 13: 221–245.

Monteiro JS, Sarmento PSM, Sotão HMP. 2019. Saprobic conidial fungi associated with palm leaf litter in eastern Amazon, Brazil. Anais da Academia Brasileira de Ciências 91: e20180545. https://doi.org/10.1590/0001-3675201920180545

Okane I, Nakagiri A, Ito T. 2001. *Surculiseries rugispora* gen. et sp. nov., a new endophytic mitosporic fungus from leaves of *Bruguiera gymnorrhiza*. Mycoscience 42: 115–122. https://doi.org/10.1007/BF02463984

Qiu L, Zhang K, Zhang XG, Castañeda-Ruíz RF, Ma J. 2020. *Blodgettia chinensis* and *Nigrolentilocus saprophyticus* spp. nov., and a first record of *Anapleurothecium botulisporum* from southern China. Nova Hedwigia 111: 449–458.

https://doi.org/10.1127/nova_hedwigia/2020/0608

Santos RF, Sotão HMP, Monteiro JS, Gusmão LFP, Hernández-Gutiérrez A. 2018. Conidial fungi associated with leaf litter of red cedar (*Cedrela odorata*) in Belém, Pará (eastern Brazilian Amazon). Acta Amazonica 48: 230–238. https://doi.org/10.1590/1809-4392201704411

Schweinitz LD. 1832. Synopsis fungorum in America boreali media degentium. Transactions of the American Philosophical Society 4: 141–316.

Seifert K, Morgan-Jones G, Gams W, Kendrick B. 2011. The genera of hyphomycetes. CBS Biodiversity Series 9. 997 p.

Sharma R, Panwar KS. 1986. A new species of *Podosporium*. Current Science 55: 1091–1092.

Taylor JE, Hyde KD. 2003. Microfungi of tropical and temperate palms. Fungal Diversity Research Series 12. 458 p.

Wang JY, Zhang K, Yang CL, Xia JW, Ma YR, Gao JM, Li XY, Zhang XG, Cai YM. 2016. *Podosporium bacilliforme* sp. nov. and a first record of *Phaeoblastophora peckii* from southern China. Mycotaxon 131: 841–846. https://doi.org/10.5248/131.841

Zhang YD, Ma J, Ma LG, Zhang XG. 2011 ["2010"]. A new species of *Podosporium* and a new record from southern China. Mycotaxon 114: 401–405. https://doi.org/10.5248/114.401

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 239–243

https://doi.org/10.5248/137.239

Ellisembia appendiculata sp. nov. from Hainan, China

Rong-Yu Liu[1], Li-Guo Ma[2], Shu-Bing Liu[1], Zhao-Xue Zhang[1], Xiu-Guo Zhang[1], Ji-Wen Xia[1*]

[1] *Shandong Provincial Key Laboratory for Biology of Vegetable Diseases and Insect Pests, College of Plant Protection, Shandong Agricultural University, Taian, Shandong 271018, China*

[2] *Shandong Key Laboratory of Plant Virology, Institute of Plant Protection, Shandong Academy of Agricultural Sciences, Jinan, 250100, China*

* Correspondence to: *xiajiwen163@163.com; xiajiwen1@126.com*

Abstract—*Ellisembia appendiculata* is described and illustrated as a new species from a specimen collected on dead branches of an unidentified broadleaf tree in Hainan Province. The fungus is characterized by distinct, unbranched conidiophores with monoblastic conidiogenous cells that produce distoseptate, obclavate or ellipsoidal conidia with 1–2 filiform, hyaline, aseptate, simple or branched appendages.

Key words—hyphomycetes, mitosporic fungi, taxonomy

Introduction

Ellisembia was introduced by Subramanian (1992) to accommodate *Sporidesmium*-like species with determinate or irregularly percurrently extending conidiogenous cells that produce distoseptate conidia. Wu & Zhuang (2005) merged *Imicles* Shoemaker & Hambl. (Shoemaker & Hambleton 2001) into *Ellisembia* and expanded the generic concept to include species that produce typically lageniform, ovoid, or doliiform percurrently extending conidiogenous cells. However, Seifert & al. (2011) retained *Imicles* as a separate genus due to the absence of molecular DNA data for the type species of *Ellisembia* and *Imicles*, and this treatment was followed by Su & al. (2016) and Hyde & al. (2019).

Hainan Province (18.17°–20.17°N 108.62°–111.08°E) is an island in southern China, with annual mean temperature of 22–27 °C, and the annual precipitation of 1000–2600 mm. Bawangling National Nature Reserve, located in the southeast of Changjiang Li autonomous county, Hainan Province, has a typical tropical rainforest climate. Among our fungal collections from this region, we found a hyphomycetous fungus that conformed with *Ellisembia* Subram. It is described and illustrated here as a new species, *E. appendiculata*.

Materials and methods

Samples of dead branches were collected from Bawangling National Nature Reserve of Hainan Province, China, and taken to the laboratory in zip-lock plastic bags. Samples were processed and examined following the methods described in Ma & al. (2011). Micromorphological characters were observed using an Olympus SZX10 stereomicroscope and Olympus BX53 microscope, both fitted with Olympus DP80 high definition colour digital cameras to photo-document fungal structures. Conidia were measured at their widest point. The range between minimum and maximum values for microscopic measurements is given. Adobe Photoshop CS5 was used for image processing to assemble photographs into plates. Single spore cultures did not grow on PDA at 25 °C after several attempts and therefore only morphological data are used here. The studied specimens are deposited in the Herbarium of Plant Pathology, Shandong Agricultural University, Taian, China (HSAUP).

Taxonomy

Ellisembia appendiculata J.W. Xia, R.Y. Liu & X.G. Zhang, **sp. nov.** Fig. 1

MB 843925

Differs from other *Ellisembia* spp. by its obclavate or ellipsoidal conidia with 1–2 filiform, hyaline, aseptate, simple or branched appendages.

Type: China, Hainan Province: Bawangling National Nature Reserve, on dead stems of an unidentified broadleaf tree, 21 May 2021, R.Y. Liu (**Holotype**, HSAUP BWL1581).

Etymology: *appendiculata*, refers to the conidia that have appendages.

Colonies on natural substrate effuse, pale brown to brown, hairy. Mycelium partly superficial, partly immersed in the substrate, composed of septate, pale brown, smooth, 2–4 µm diam. Conidiophores differentiated, single, erect, straight or slightly flexuous, cylindrical, smooth, thick-walled, brown to dark brown, 2–4-septate, 35–60 × 6.5–8 µm. Conidiogenous cells monoblastic, integrated, terminal, brown to dark brown, 15.5–30 × 6–7.5 µm. Conidial secession schizolytic. Conidia solitary, acrogenous, obclavate or ellipsoidal, smooth-walled, pale brown to brown, 10–12-distoseptate, 50–72 × 11.5–15 µm; apical cell extended into 1–2 filiform, hyaline, aseptate, simple

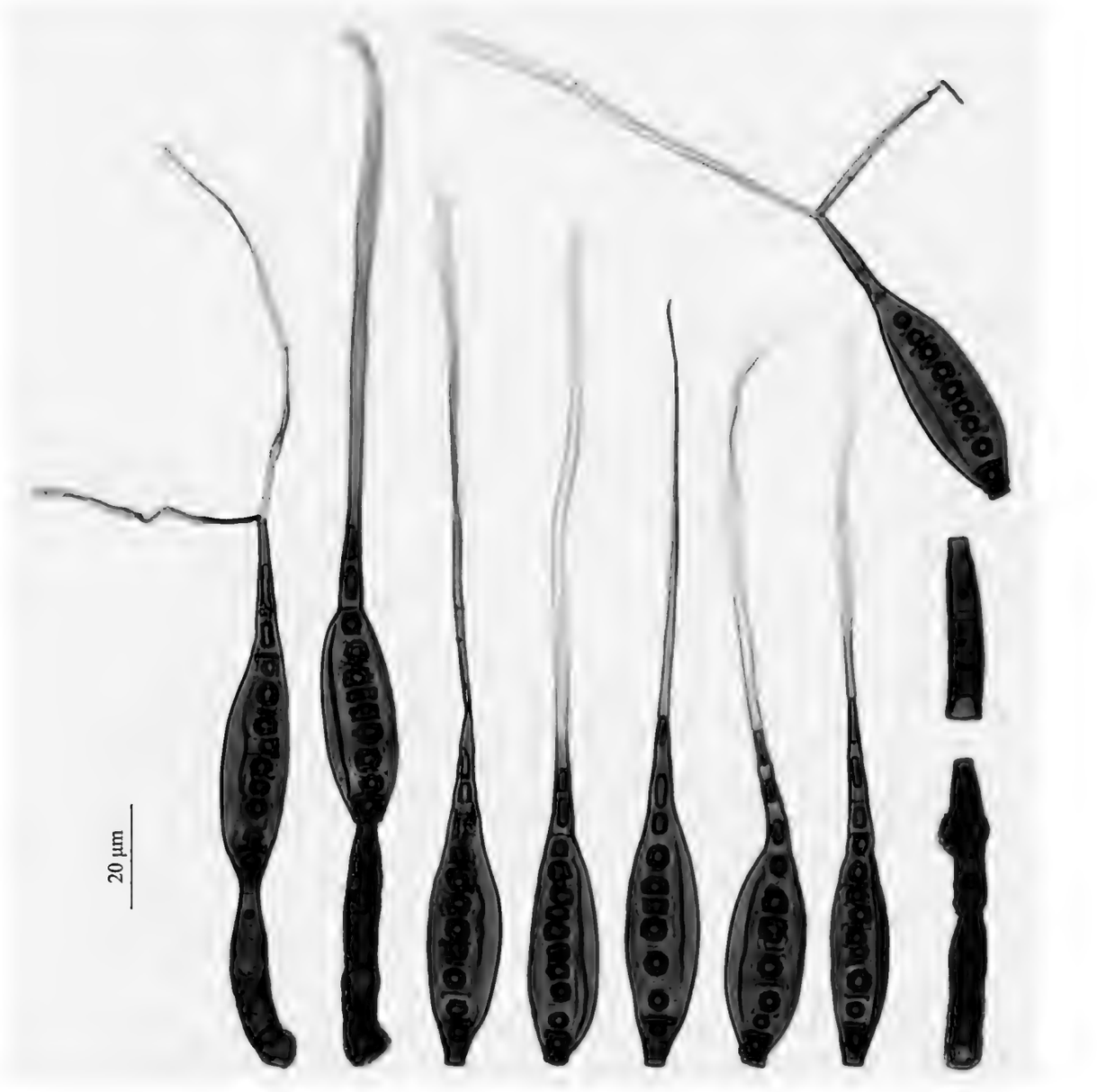


Fig. 1. *Ellisembia appendiculata* (holotype, HSAUP BWL1581). Conidiophores, conidiogenous cells, and conidia.

or branched appendages, 65–120 × 1–3 µm; basal cell conical truncate, darker than other cells, 3.5–5 µm diam. at the base.

Comments – *Ellisembia appendiculata* is morphologically similar to *E. brachypus* (Ellis & Everh.) Subram., *E. filia* W.P. Wu, *E. flagelliformis* (Matsush.) W.P. Wu, and *E. magnibrachypus* (Matsush.) Rajeshk. & S.K. Singh in conidial shape, especially in possessing filiform, hyaline, aseptate appendages (Matsushima 1975, Subramanian 1992, Wu & Zhuang 2005, Rajeshkumar

& al. 2012). However, *E. appendiculata* differs from *E. brachypus*, *E. filia* and *E. magnibrachypus* in its number of conidial distosepta and conidial size, and from *E. flagelliformis* in its wider conidia with fewer distosepta (Table 1).

Table 1. Morphological comparison of *Ellisembia appendiculata* with similar species. The new species is set in bold font.

Species	Conidiophores (μm)	Conidia		
		Size (μm)	Septa	Appendages (μm/branching?)
E. appendiculata	**35–60 × 6.5–8**	**50–72 × 11.5–15**	**10–12**	**65–120 × 1–3/yes**
E. brachypus [2]	30–250 × 5–9	50–90 × 10–14	5–8	30–74 × 2–3/no
E. filia [2]	15–20 × 4–5	40–50 × 7–8	7–9	≤50 × 0.5–1/no
E. flagelliformis [2]	30–65 × 4–5	65–90× 9–10	11–14	≤40 × 1–3/no
E. magnibrachypus[1]	80–160 × 7–8	48–62 × 12–14	9–10	≤65 long/yes

* Data from [1] Matsushima (1975); [2] Wu & Zhuang (2005).

Acknowledgments

The authors express gratitude to Dr. Jian Ma (College of Agronomy, Jiangxi Agricultural University, Nanchang, Jiangxi, China) and Dr. Yue-Hua Geng (College of Plant Protection, Henan Agricultural University, Zhengzhou, Henan, China) for serving as pre-submission reviewers and to Dr. Shaun Pennycook for nomenclatural review and Dr. Lorelei L. Norvell for editorial review. This project was supported by the National Natural Science Foundation of China (Nos. 31900014, U2002203, 31750001).

Literature cited

Hyde KD, Tennakoon DS, Jeewon R, Bhat DJ, Maharachchikumbura SSN, Rossi W & al. 2019. Fungal diversity notes 1036–1150: taxonomic and phylogenetic contributions on genera and species of fungal taxa. Fungal Diversity 96: 1–242. https://doi.org/10.1007/s13225-019-00429-2

Ma J, Wang Y, O'Neill NR, Zhang XG. 2011. A revision of the genus *Lomaantha*, with the description of a new species. Mycologia 103(2): 407–410. https://doi.org/10.3852/10-176

Matsushima T. 1975. Icones microfungorum a Matsushima lectorum. Published by the author, Kobe, Japan.

Rajeshkumar KC, Kajale S, Sutar S, Singh SK. 2012. *Ellisembia karadkensis* sp. nov. from southern Western Ghats, India. Mycotaxon 121:181–186. https://doi.org/10.5248/121.181

Seifert K, Morgan-Jones G, Gams W, Kendrick WB. 2011. The genera of hyphomycetes. CBS Biodiversity Series 9. 997 p.

Shoemaker RA, Hambleton S. 2001. "*Helminthosporium*" *asterinum*, *Polydesmus elegans*, *Imimyces*, and allies. Canadian Journal of Botany 79: 592–599. https://doi.org/10.1139/b01-038

Su HY, Hyde KD, Maharachchikumbura SSN, Ariyawansa HA, Luo ZL, Promputtha I & al. 2016. The families *Distoseptisporaceae* fam. nov., *Kirschsteiniotheliaceae*, *Sporormiaceae* and

Torulaceae, with new species from freshwater in Yunnan Province, China. Fungal Diversity 80: 375–409. https://doi.org/10.1007/s13225-016-0362-0

Subramanian CV. 1992. A reassessment of *Sporidesmium* (hyphomycetes) and some related taxa. Proceedings of the Indian National Science Academy, B 58: 179–190.

Wu WP, Zhuang WY. 2005. *Sporidesmium*, *Endophragmiella* and related genera from China. Fungal Diversity Research Series 15. 351 p.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 245–249

https://doi.org/10.5248/137.245

Passalora sicerariae sp. nov. on *Lagenaria siceraria* from India

Anu Singh[1], H.D. Bhartiya[1], P.N. Singh[2]*

[1] *Mycopathology Laboratory, Department of Botany, Bipin Bihari P.G. College, Jhansi (U.P)-284001, India*

[2] *National Fungal Culture Collection of India (NFCCI), Biodiversity and Palaeobiology Group, MACS' Agharkar Research Institute, GG Agarkar Road, Pune-411004, India*

* Correspondence to: *pnsingh@aripune.org*

Abstract—A new species, *Passalora sicerariae*, occurring on *Lagenaria siceraria* (bottle gourd) collected in Madhya Pradesh, India, is illustrated and described. It is characterized by ovoid, cyclindrical-obclavate, obclavate, broadly navicular to sub-reniform, pale brown conidia. The new hyphomycete is compared with four other *Passalora* species that occur on *Cucurbitaceae*.

Key words—Bundelkhand region, cercosporoid fungi, *Mycosphaerellaceae,* taxonomy

Introduction

Since Fries (1849) established the genus *Passalora*, about 750 *Passalora* species have been reported. These cercosporoids are common on a wide range of both angiosperms and gymnosperms including horticultural and vegetable crops. New species, new records, and additions to the distribution of cercosporoid fungi have been provided by Chupp (1954), Deighton (1976), Ellis (1976), Crous (1998), Crous & Braun (2003), Braun & Crous (2006), Kamal (2010), and Singh & al. (2008, 2011, 2013). *Passalora* species can cause serious foliar infection resulting in death of leaves. The genus is characterized by the presence of well-developed stromata, sporodochial conidiomata, macronematous conidiophores, and septate conidia that are

pigmented and smooth to finely verruculose with a darkened, thickened, refractive scar (Fries1849, Crous & Braun 2003).

In recent surveys for foliicolous pathogens, many collections of *Passalora* were made in India. One January 2018 survey explored the microfungal diversity in the natural forest of Orchha situated in the northeastern Bundelkhand region of India at elevations of 210–314 m asl. in primarily deciduous forests with an annual rainfall ≤1000 mm. Among the specimens collected was an undescribed *Passalora* species, which we describe and illustrate here.

Materials & methods

Collected specimens were taken to the laboratory in separate paper bags. Free-hand cut sections were taken through infection spots and mounted in lactic acid and cotton blue on glass slides and examined using microscopes. A trinocular Weswox SMZ-33589 microscope (aided with Digi-CAM) was used to study features of the fungus on substrates. Drawings of various morphological structures were done with the help of a camera lucida and measured with a micrometer. The holotype specimen was deposited in Ajrekar Mycological Herbarium, MAC'S Agharkar Research Institute, Pune, India (AMH) and isotype specimen was deposited in Anu Singh Mycological Herbarium, Bipin Bihari P.G. College, Jhansi, Uttar Pradesh, India, (ASMH).

Taxonomy

Passalora sicerariae Anu Singh, Bhartiya & P.N. Singh, **sp. nov.** Fig. 1

MB 835143

Differs from all other *Passalora* spp. on *Cucurbitaceae* (*P. cayaponiae, P. cucurbiticola, P. guraniae,* and *P. momordicae*) by its longer conidiophores, smaller conidia, and higher number of conidial septa.

Type: India, Uttar Pradesh, Jhansi, Orchha Forest, on living leaves of *Lagenaria siceraria* (Molina) Standl. (*Cucurbitaceae*), 10 Jan 2018, coll. Anu Singh (**Holotype**, AMH 10152; **isotype**, ASMH 108).

Etymology: Specific epithet refers to the host species.

Infection spots amphigenous, circular to subcircular and spreading on entire leaf surface, light brown, 1–8 mm diam. Colonies amphigenous, effuse, punctiform, light brown to greenish. Mycelium internal, unbranched, septate, smooth-walled, hyaline. Stromata well-developed, immersed in the substratum, light brown, 24–75 µm diam. Conidiophores macronematous, mononematous,1–9-fasciculate, erect to procumbent, straight to flexuous, geniculate, smooth, thin-walled, unbranched, 0–7-septate, olivaceous brown, 22–122 × 2–4 µm. Conidiogenous cells integrated, terminal to intercalary

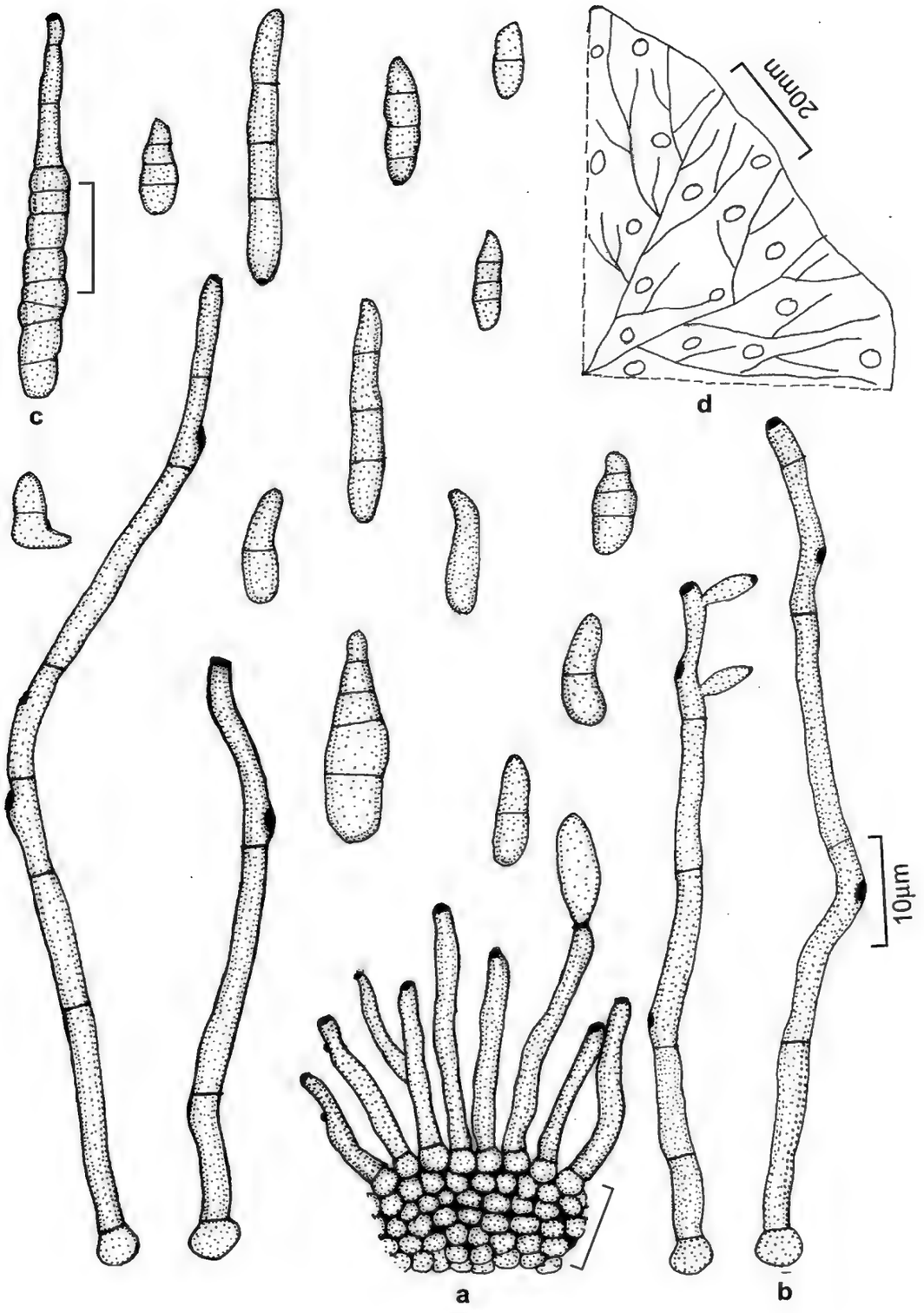


Fig. 1. *Passalora sicerariae* (holotype, AMH 10152).
a. Stroma; b. Conidiophores and conidiogenous cells; c. Conidia; d. Leaf spots.
Scale bars: a–c = 10 µm; d = 20 mm.

or lateral, sympodial, smooth-walled, ellipsoidal. Conidia solitary, acrogenous ovoid, cyclindrical-obclavate, obclavate, broadly navicular to slightly curved, base obconico-truncate, 1–10-septate, 8–46 × 3–4 µm, dry, smooth-walled, pale brown, hilum somewhat thickened.

Discussion

Passalora sicerariae has been databased in Facesoffungi as FoF07931.

Although the fungal databases of Farr & Rossman (2021) do not cite any *Passalora* species on the host genus *Lagenaria,* they do report four *Passalora* species on other genera of *Cucurbitaceae: P. cucurbiticola* (Henn.) U. Braun & Crous, *P. momordicae* (Heald & F.A. Wolf) U. Braun & Crous, *P. cayaponiae* (F. Stevens & Solheim) U. Braun & Crous, and *P. guraniae* R. Kirschner.

Morphological comparison of our collection with these species (Table 1) supports taxonomic separation between *P. sicerariae* and the four closely related taxa. *Passalora sicerariae* conidiophores are longer and narrower compared to *P. cucurbiticola, P. cayaponiae, P. momordicae P. guraniae*, while

Table 1. Comparison of morphological features of *Passalora* species known on *Cucurbitaceae.*

Species	Stromata	Conidiophores	Conidia
P. cayaponiae	Rare; non-fasciculate or if massed, resembling pseudo-fascicles	Irregular in width, multi-septate, branched, procumbent, spore scar on rounded tip, pale olivaceous brown, 45–100 × 4–6 µm	Obclavate-cylindric, rounded to long obconic-truncate base, obtusely rounded tip, subhyaline to pale yellowish brown, 25–110 × 4–6 µm
P. momordicae	Substomatal, olivaceous brown 10–30 µm diam.	Erect, usually divergent, septate, geniculate, occasionally branched, flexuous, scars thickened, olivaceous brown, 10–50 × 3–5 µm	Catenate, occasionally in branched chains, subcylindric, 0–7-septate, end obtuse to subtruncate, pale olivaceous, 20–80 × 3–5 µm
P. guraniae	Absent	From superficial mycelium, irregularly branched, often forming fascicles by intertwining & anastomosing, pale brown, almost smooth, ≤100 µm long	In branched chains, cylindrical or obclavate-cylindrical; straight or slightly curved, distinctly verruculose, 0–4-septate, with thicker darkened scars at the base pale to medium brown, 21–51 × 3.5–5.5 µm,
P. sicerarae	Well-developed, dark brown 24–75 µm diam.	1–9-fasciculate, smooth, straight to flexuous geniculate, unbranched thin-walled, reduced to conidiogenous cells, olivaceous brown, 22–122 × 2–4 µm	Cylindrical-obclavate, broadly navicular or sub-reniform, base rounded, obconico-truncate, hila thickened, 1–10-septate, pale brown, 8–46 × 3–4 µm

only *P. cucurbiticola* and *P. sicerariae* possess fasciculate conidiophores. Additionally, conidia in *P. sicerariae* are shorter and the number of conidial septa is greater than found in the other four species. Based on these significant morphological differences, we propose *P. sicerariae* as a new species.

Acknowledgments

Authors thank the Principal, Bipin Bihari PG College Jhansi, for providing library and laboratory facilities. Authors especially wish to express sincere gratitude to Drs. Rafael F. Castaneda-Ruiz (Instituto de Investigaciones Fundamentales en Agricultura Tropical (INIFAT), 'Alejandro de Humboldt,' La Habana, Cuba) and Eric McKenzie (Manaaki Whenua Landcare Research, Auckland, New Zealand) for reviewing the manuscript. Authors also thank the Curator, Ajrekar Mycological Herbarium (Agharkar Research Institute, Pune, India) who assigned the AMH number. Thanks, are also due to UGC Government of India, New Delhi for providing financial support under RGNF programme for the first author.

Literature cited

Braun U, Crous PW. 2006. Proposal to conserve the name *Pseudocercospora* against *Stigmina* and *Phaeoisariopsis* (hyphomycetes). Taxon 55(3): 801-808. https://doi.org/10.2307/25065660

Chupp C. 1954. A monograph of the fungus genus *Cercospora*. Ithaca, New York. Published by the author.

Crous PW. 1998. *Mycosphaerella* spp. and their anamorphs associated with leaf spot diseases of *Eucalyptus*. Mycological Memoir 21. 170 p.

Crous PW, Braun U. 2003.*Mycosphaerella* and its anamorphs and *Passalora*. CBS, Utrecht. 571 p.

Deighton FC. 1976. Studies on *Cercospora* and allied genera VI. *Pseudocercospora* Speg., *Pantospora* Cif. and *Cercoseptoria* Petr. Mycological Papers 140. 168 p.

Ellis MB.1976. More dematiaceous hyphomycetes. International Mycological Institute, Surrey, England.

Farr DF, Rossman AY. 2021. Fungal Databases, U.S. National Fungus collections, ARS, USDA. Retrieved January 23, 2021, from https://nt.ars-grin.gov/fungal databases/

Fries EM. 1849. Summa vegetabilium. Scandinaviae. Sectio posterior. Typographia Academica. Uppsala.

Kamal. 2010. Cercosporoid fungi of India. Bisan Singh, Mahendra Pal Singh Publication, Dehradun (UK) India.

Singh SK, Singh PN, Mishra P. 2008. New species of *Passalora* (cercosporoid hyphomycetes) from Western Ghats, India. Czech Mycology 60(2): 243-249. https://doi.org/10.33585/cmy.60208

Singh R, Kumar S, Kamal. 2011. Two new species of *Passalora* and *Pseudocercospora* from north eastern U.P., India. Mycotaxon 117: 137–143. https://doi.org/10.5248/117.137

Singh R, Kumar S, Saini DC, Upadhyaya PP, Kamal, Braun U. 2013. Diversity of *Passalora* on *Ficus*. Mycological Progress 12: 637–643. https://doi.org/10.1007/s11557-012-0870-6

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 251–259

https://doi.org/10.5248/137.251

Andomyces coronatus gen. & sp. nov. from Thailand

Veera Sri-indrasutdhi*, Charuwan Chuaseeharonnachai, Sayanh Somrithipol

National Center for Genetic Engineering and Biotechnology (BIOTEC), 113 Thailand Science Park, Phahonyothin Road, Khlong Nueng, Khlong Luang, Pathum Thani 12120, Thailand

* Correspondence to: *veera@biotec.or.th*

Abstract—A new genus and species, *Andomyces coronatus*, found on submerged decaying wood from freshwater habitat in Thailand, is described and compared with similar genera such as *Polyschema*, *Torula,* and *Acrophragmis*. The new dematiaceous genus is morphologically characterized by micronematous conidiophores; globose to subglobose, discrete, smooth, conidiogenous cells; schizolytic conidial secession; and didymosporous, distoseptate, smooth conidia. The distinguishing features of the new species are provided in the description and illustrations.

Key words—asexual fungi, hyphomycetes

Introduction

During surveys of hyphomycetes conducted in freshwater streams in Thailand during 2013-15 (Chuaseeharonnachai & al. 2014), an unusual dematiaceous hyphomycete was found on submerged woody materials at a waterfall. The fungus possessed a combination of morphological features that did not fit any described dematiaceous hyphomycete genera (Matsushima 1980, 1985, 2001; Ellis 1971, 1976; Wu & Zhuang 2005; Castañeda Ruíz & al. 2009; Seifert & al. 2011; Crous & al. 2015; Li & al. 2017). We accordingly propose a new genus and species, *Andomyces coronatus,* based on morphological data.

Materials & methods

Fresh specimens were collected from the riverbank of a waterfall, located in Pak Chong District, Nakhon Ratchasima Province (14.43°N 101.37°E). Fungal specimens were brought to the laboratory in Ziplock plastic bags and incubated in plastic boxes lined with moistened tissue papers at room temperature (22-25 °C) for 2 weeks. Specimens were examined for fungal colonies with an Olympus SZ61 stereomicroscope. Fungal structures were picked up and transferred using a sterile fine-tipped needle to a drop of distilled water on a glass slide and covered by a coverslip. The fungal features were examined under an Olympus CX31 compound microscope and photographed using an Olympus DP70 differential interference contrast microscope. The characteristic features of asexual morph ascomycetes were observed and measured under a scaled microscope. Isolation was attempted on various media (Difco™: potato dextrose agar, corn meal agar and malt extract agar; Himedia™: potato carrot agar) and incubated at room temperature (22-25 °C), but no conidial germination was observed and therefore the fungus could not be cultured. The type specimen is deposited at Fungarium Biotec Bangkok Herbarium (BBH), Thailand (https://www.nbt-microbe.org/fungarium).

Taxonomy

Andomyces Chuaseehar., Sri-indr. & Somrith., **gen. nov.**

MB 823025

Differs from *Polyschema, Torula,* and *Acrophragmis* in having micronematous, cylindrical conidiophores, globose to subglobose conidiogenous cells, and distoseptate conidia.

Type species: *Andomyces coronatus* Chuaseehar. & al.

Etymology: referring to Professor Dr. Katsuhiko Ando, in recognition for his significant contributions to freshwater mycology and-*myces:* referring to fungi.

Colonies on natural substrate, loosely confluent, punctiform, pulvinate, blackish brown to black. Mycelium in the substrate composed of septate, branched, smooth or verrucose, brown hyphae. Conidiophores micronematous, mononematous, cylindrical, branched, smooth or verrucose. Conidiogenous cells monoblastic, discrete, terminal, determinate, globose to subglobose, smooth or verrucose. Conidial secession schizolytic. Conidia holoblastic, acrogenous, solitary, didymosporous, distoseptate, with globular cell lumen, smooth or verrucose, thick walled, with the median part bearing a circle of knobs on the cell wall when mature.

Sexual morph: unknown.

Andomyces coronatus Chuaseehar., Sri-indr. & Somrith., **sp. nov.** Figs 1, 2

MB 823026

Differs from *Acrophragmis* spp. by its micronematous, cylindrical conidiophores, its globose to subglobose conidiogenous cells, and its distoseptate conidia.

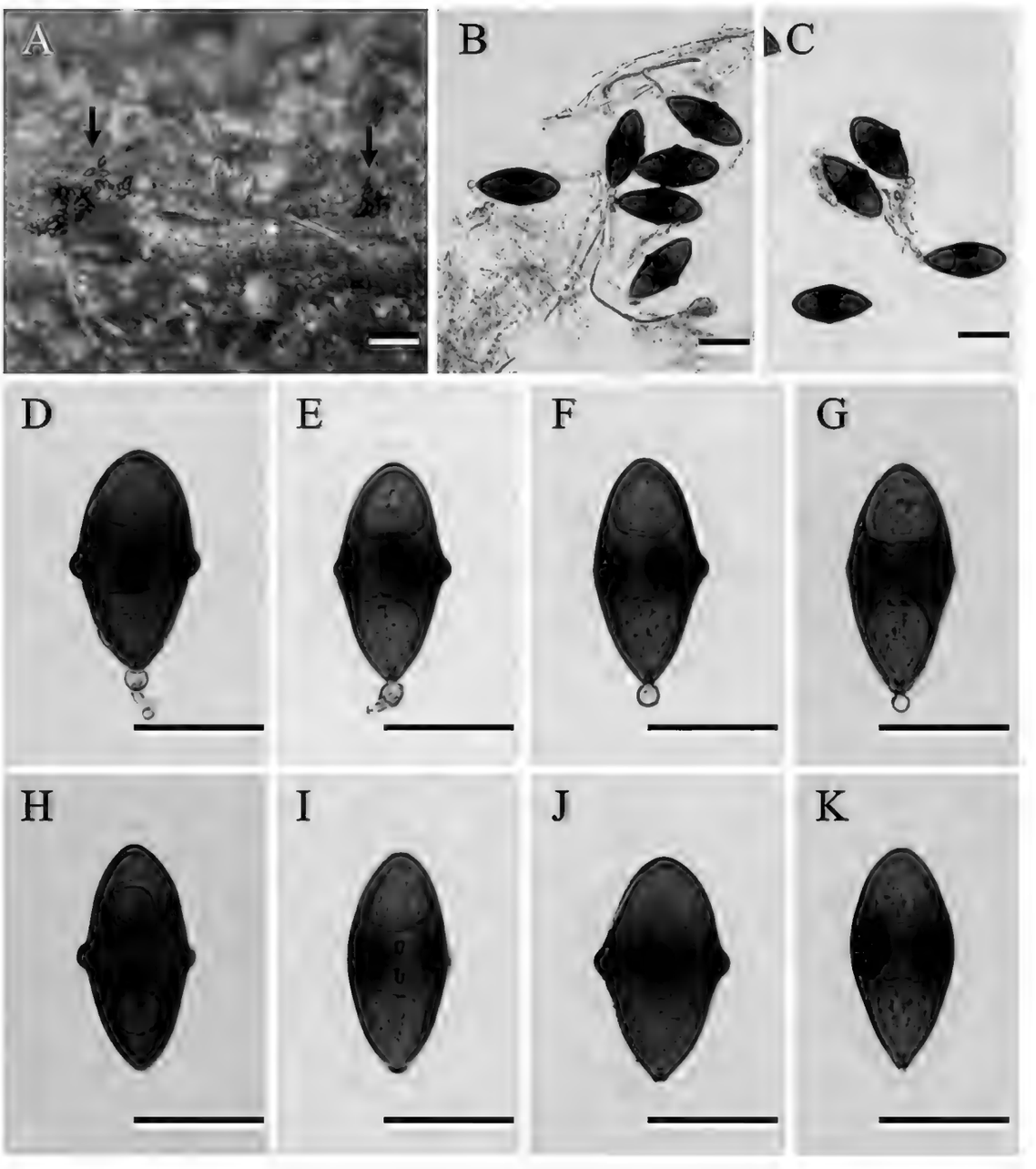


Fig. 1. *Andomyces coronatus* (holotype, BBH40836). A. Colonies scattered on submerged decaying wood, arrowed; B, C. Squash mount of a portion of colonies showing conidiophores, conidiogenous cells, and conidia; D–G. Conidia with conidiogenous cells; H–K. Conidia. Scale bars = 25 μm.

Type: Thailand, Nakhon Ratchasima Province, Pak Chong District, 14.43°N 101.37°E, c. 740 m a.s.l., on unidentified submerged decaying wood, 1 November 2014, C. Chuaseeharonnachai (**Holotype:** BBH 40836).

Etymology: *coronatus*, referring to the conidia, which are shaped like a crown.

Culture: not obtained. Colonies on natural substratum, loosely confluent, punctiform, pulvinate, blackish brown to black. Mycelium partly superficial and partly immersed in the substrate, composed of branched, septate, smooth walled, pale brown to brown, thick walled, 2–2.5 µm wide hyphae. Conidiophores micronematous, mononematous, cylindrical, branched, 1–6-septate, smooth to rough walled, hyaline to pale brown, ≤175 µm long, 1.5–2.5 µm wide; mostly 30–55 × 2–2.5 µm. Conidiogenous cells monoblastic, discrete, terminal, determinate, globose to subglobose, smooth walled, hyaline to pale brown, 3.75–5 µm diam. $x = 4.77$ µm; $n = 30$). Conidial secession schizolytic. Conidia holoblastic, acrogenous, solitary, dry, biconic, 1-distoseptate, with large cell lumen (10–12.5 × 3.75–5 µm) connecting between proximal and distal cells, smooth walled, brown to dark brown, with the blackish-brown to black median part, projecting a circle of equidistant 4-5 hemispherical knobs (5 µm wide, 2.5 µm thick) when mature, 40–47 µm long, 20–27.5 µm wide at the broadest part ($x = 43.6 \times 24.7$ µm; $n = 40$), rounded at apex, subulate basal cell with a circular scar at the base on secession. Globose conidiogenous cells often remain attached to basal point of detached conidia.

Sexual morph: unknown.

Discussion

On its natural substrate, *Andomyces coronatus* produces groups of black conidia that may resemble those of several genera, such as *Conioscypha, Parafuscosporella, Vanakripa,* or *Fuscosporella*. However, these genera have euseptate conidia, whereas *A. coronatus* has distoseptate conidia. The distoseptum of *A. coronatus* is thick with the type of septal pore (Figs 1G, 2G) noted by Ho & Hyde (2004). Septal types (distoseptum vs euseptum) are helpful in separating several genera, such as *Corynespora* vs *Solicorynespora* and *Podosporiopsis* vs *Podosporium* (Ma & al. 2016). Anamorphic fungi with black distoseptate conidia are uncommon, clearly distinguishing *A. coronatus* from any previously described taxon.

Andomyces is morphologically most similar to *Polyschema* H.P. Upadhyay, *Torula* Pers., and *Acrophragmis* Kiffer & Reisinger in producing dark brown to black colonies, superficial or immersed pale brown to brown mycelia, and darkened conidia (Persoon 1795, Upadhyay 1966; Ellis 1976, Wu & Zhuang 2005, Seifert & al. 2011, Crous & al. 2015).

The conidia of *Andomyces coronatus* are superficially similar to *Acrophragmis* in having a ring of small protuberant knobs on the conidial

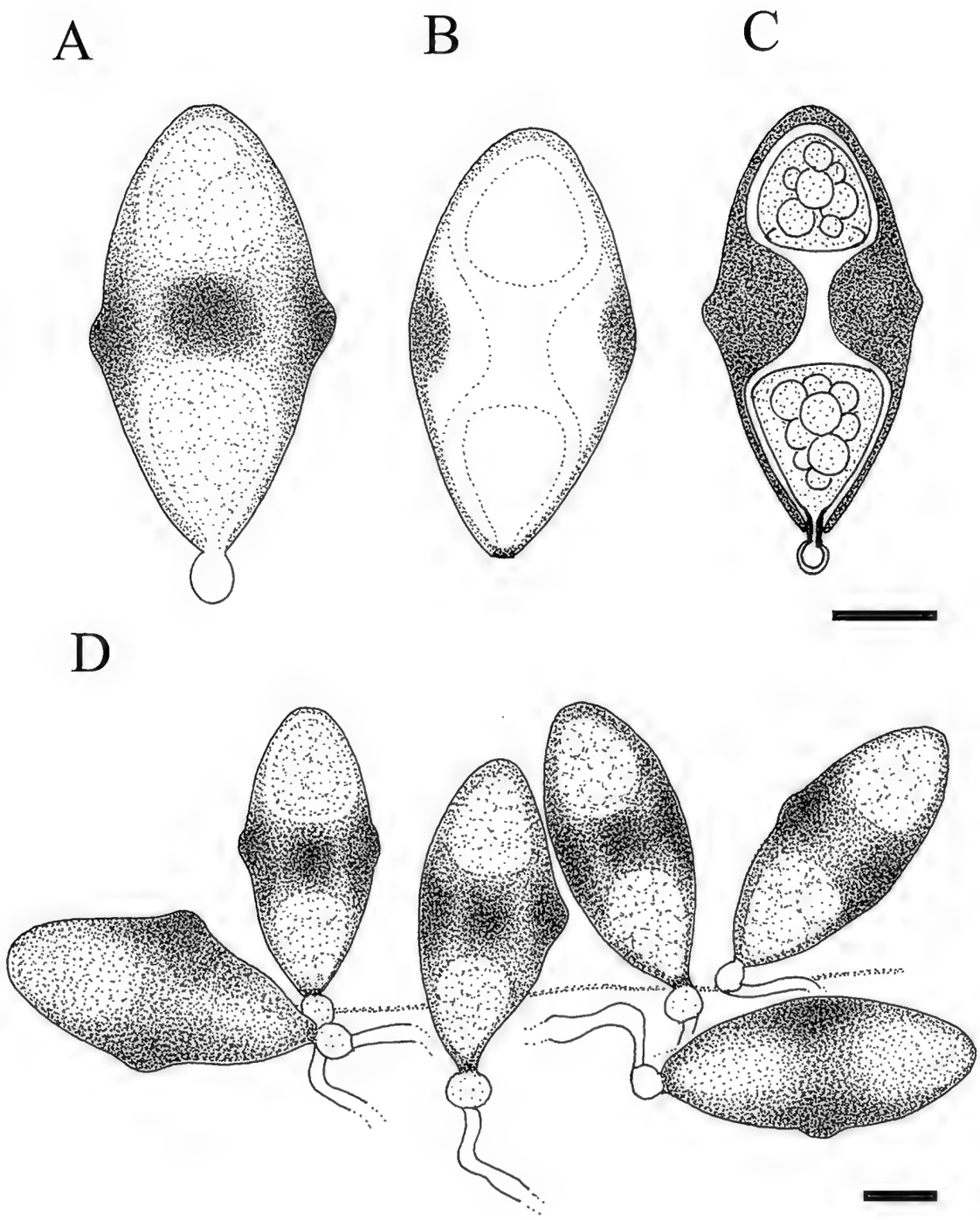


FIG. 2. *Andomyces coronatus* (holotype, BBH40836).
A, B. Outside view of conidia; C. Conidial cross section showing the cell lumen that connects the proximal and distal cells; D. Colonies on natural submerged decaying wood.
Scale bars = 10 μm. ARTIST: Sayanh Somrithipol.

Table 1. Comparative morphological characters of *Andomyces* and closely related anamorphic genera.

Character	*Polyschema*[1]	*Torula*	*Acrophragmis*	*Andomyces*
Colony	Flattened, floccose, woolly; dark-green, brown to dark brown, or greenish black; sporulating abundantly.	Discrete, effuse, dry, velvety; dark brown to black	Effuse, often inconspicuous; hairy; brown	Loosely confluent, punctiform, pulvinate; blackish-brown to black.
Conidiophore	Present or absent, short or long, decumbent, micronematous, mononematous, simple, peg-like, torulose, cylindrical at the base, wider toward the apex, arising laterally from the hyphae, olivaceous or pale brown, 0–3-septate.	Macro/micronematous, often reduced to conidiogenous cells, or with one brown supporting cell, verrucose, mononematous, brown.	Macronematous, mononematous, single or aggregated at the base, unbranched, pale brown to dark brown, with percurrent proliferations.	Micronematous, mononematous, cylindrical, branched or unbranched, smooth or verrucose.
Conidiogenous cells	Produced on repent hyphae or conidiophores, singly and form conidium through isthmus or without isthmus, pale brown to brown.	Solitary on mycelium, erect, doliiform to ellipsoid or clavate, brown, smooth to verruculose, mono- to polyblastic.	Integrated, terminal, holoblastic, cylindrical, smooth, pale brown to brown, percurrent.	Monoblastic, discrete, terminal, determinate, globose to subglobose, smooth or verrucose.
Conidial septa	Euseptate	Euseptate	Euseptate	Distoseptate
Conidia	Didymosporous phragmosporous, or muriform, brown, single, dry.	Phragmosporous, monilioid, brown, in acropetal branched chains, dry.	Phragmo- or staurosporous, central cell dark, polar cells hyaline, multiple protuberances, single, dry.	Didymosporous or occasionally phragmosporous, holoblastic, acrogenous, solitary, smooth or verrucose, with the median part bearing, equidistant, 4–5 protuberant knobs on the surface.
Substratum	Soil, wood, litter	Decaying wood	Dead branches of woody plant	Submerged decaying wood

[1] described based on agar media

cell wall. However, the new species possesses micronematous, cylindrical conidiophores, globose to subglobose conidiogenous cells, and distoseptate conidia, whereas *Acrophragmis* is characterized by macronematous, long stalked conidiophores, integrated, percurrent conidiogenous cells, and acrogenous solitary oblong to cylindrical 3-euseptate conidia (Kiffer & Reisinger 1970, Ellis 1976, Rao & de Hoog 1986, Seifert & al. 2011).

Andomyces coronatus differs from *Polyschema* species in having branched or unbranched cylindrical conidiophores, monoblastic conidiogenous cells, and holoblastic, distoseptate conidia (Figs 1A–C, 2D). In contrast, *Polyschema* has conspicuous or undifferentiated conidiophores, mono- or polytretic globose to slightly clavate conidiogenous cells, and distinct euseptate conidia (Upadhyay 1966; Ellis 1976; Reisinger & Kiffer 1974; Pandeya & Saksena 1978; Castañeda-Ruíz & al. 1996, 2000; Seifert & al. 2011).

Torula and related genera—*Rutola* J.L. Crane & Schokn. and *Latorua* Crous—can be distinguished from *Andomyces coronatus* by the morphology of their conidiophores which are reduced to conidiogenous cells, as well as the presence of supporting cells or the conidial chains composed of brown blastic doliiform to ellipsoidal conidiogenous cells (Persoon 1795, Ellis 1971, Crane & Schoknecht 1977, Matsushima 1980, Seifert & al. 2011, Crous & al. 2015, Su & al. 2016, Li & al. 2017). In contrast, *A. coronatus* conidia characteristically have a cell lumen that connects the proximal and distal cells and a conidiogenous cell that often remains adhered to the basal attachment point. (Fig. 2B, C). The diagnostic characteristics of the genera discussed above are summarized in Table 1.

Even lacking cultural characters and molecular sequence data, the morphology of this fungus is sufficiently unique to warrant a new genus and a new species. The continued surveys of freshwater fungi in Thailand have provided new information to Thai biodiversity in which up to 600 species have been recorded (Sivichai & Boonyuen 2005). This fungus is an additional record of a novel species in the natural stream habitat, suggesting that other taxa may await discovery.

Acknowledgments

The authors express their gratitude to Prof. Dr. R.F. Castañeda-Ruíz (INIFAT, Cuba) for kind suggestions and improvements in the taxonomic descriptions in this manuscript. We are to indebted Dr. Nattawut Boonyuen, Dr. Satinee Suetrong, and Dr. Philip James Shaw from National Center for Genetic Engineering and Biotechnology (BIOTEC) for valuable suggestions. Dr. Jayarama Bhat (Goa University, India) and

Dr. Saowaluck Tibpromma (Chinese Academy of Sciences, China) are thanked for kindly reviewing the manuscript. Dr. Lorelei L. Norvell's editorial and Dr. Shaun Pennycook's nomenclature reviews are greatly appreciated. This study was financially supported by BIOTEC and National Science and Technology Development Agency (NSTDA), Thailand (Infrastructure: P 14-51395).

Literature cited

Castañeda-Ruíz RF, Guarro J, Cano J. 1996. Notes on conidial fungi. III. An interesting species of *Polyschema* from Cuba. Mycotaxon 57: 451–456.

Castañeda-Ruíz RF, Decock C, Saikawa M, Gene, J, Guarro J. 2000. *Polyschema obclaviformis* sp. nov., and some new records of hyphomycetes from Cuba. Cryptogamie, Mycologie 21: 215–220. https://doi.org/10.1016/S0181-1584(00)01051-4

Castañeda-Ruíz RF, Iturriaga T, Minter DW, Abarca GH, Stadler M, & al. 2009. Two new anamorphic fungi and some microfungi recorded from 'El Ávila,' Venezuela. Mycotaxon 107: 225–237. https://doi.org/10.5248/107.225

Chuaseeharonnachai C, Somrithipol S, Boonyuen N. 2014. A new species of *Fusticeps* from Thailand. Mycosphere 5: 312-317. https://doi.org/10.5943/mycosphere/5/2/5

Crane JL, Schoknecht JD. 1977. Revision of *Torula* species. *Rutola*, a new genus for *Torula graminis*. Canadian Journal of Botany 55: 3013-3019. https://doi.org/10.1139/b77-339

Crous PW, Carris LM, Giraldo A, Groenewald JZ, Hawksworth DL & al. 2015. The genera of fungi — fixing the application of the type species of generic names - G 2: *Allantophomopsis*, *Latorua*, *Macrodiplodiopsis*, *Macrohilum*, *Milospium*, *Protostegia*, *Pyricularia*, *Robillarda*, *Rotula*, *Septoriella*, *Torula*, and *Wojnowicia*. IMA Fungus 6: 163-198. https://doi.org/10.5598/imafungus.2015.06.01.11

Ellis MB. 1971. Dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey, England. 608 p.

Ellis MB. 1976. More dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey, England. 507 p.

Ho WH, Hyde, KD. 2004. A new type of conidial septal pore in fungi. Fungal Diversity 15: 171–186.

Kiffer K, Reisinger O. 1970. Contribution à l'étude de la microflore fongique du Congo I. Champignons observés sur débris végétaux et sur pièges de cellulose. Revue d'Écologie et de Biologie du Sol 7: 11-31.

Li JF, Phookamsak R, Jeewon R, Bhat DJ, Mapook A & al. 2017. Molecular taxonomy and morphological characterization reveal new species and new host records of *Torula* species (*Torulaceae*, *Pleosporales*). Mycological Progress 16: 447-461. https://doi.org/10.1007/s11557-017-1292-2

Ma J, Zhang XG, Castañeda-Ruíz RF. 2016. *Podosporiopsis*, a new genus of synnematous hyphomycetes from China. Mycotaxon 131: 773–780. https://doi.org/10.5248/131.773

Matsushima T. 1980. Matsushima Mycological Memoirs 1. Matsushima, Kobe, Japan.

Matsushima T. 1985. Matsushima Mycological Memoirs 5. Matsushima, Kobe, Japan.

Matsushima T. 2001. Matsushima Mycological Memoirs 9. Matsushima, Kobe, Japan.

Pandeya JPN, Saksena SB. 1978. A new species of *Polyschema* from Indian soil. Mycologia 70: 876-879. https://doi.org/10.1080/00275514.1978.12020298

Persoon CH. 1795. Observationes mycologicae. Annals of Botany (Usteri) 15: 1-39.

Rao V, de Hoog GS. 1986. New or critical hyphomycetes from India. Studies in Mycology 28: 8-12.

Reisinger O, Kiffer K. 1974. Contribution to the fungal microflora of the Congo. IV. *Polyschema congolensis* sp. nov.: taxonomy and ultrastructure. Transactions of the British Mycological Society 62: 289–294. https://doi.org/10.1016/S0007-1536(74)80037-9

Seifert K, Morgan-Jones G, Gams W, Kendrick B. 2011. The genera of hyphomycetes. CBS Biodiversity Series 9. 997 p.

Sivichai S, Boonyuen N, 2005. Freshwater fungi. 95–106, in: EBG Jones & al. (eds). Thai Fungal Diversity, BIOTEC, Bangkok, Thailand.

Su HY, Hyde KD, Maharachchikumbura SSN, Ariyawansa HA, Luo ZL & al. 2016. The families *Distoseptisporaceae* fam. nov., *Kirschsteiniotheliaceae*, *Sporormiaceae* and *Torulaceae*, with new species from freshwater in Yunnan Province, China. Fungal Diversity 80: 375-409. https://doi.org/10.1007/s13225-016-0362-0

Upadhyay HP. 1966. Soil fungi from North-East Brazil, II. Mycopathologia et Mycologia Applicata 30: 276-286. https://doi.org/10.1007/BF02053160

Wu WP, Zhuang WY. 2005. *Sporidesmium*, *Endophragmiella* and related genera from China. Fungal Diversity Research Series 15. 351 p.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 261–270

https://doi.org/10.5248/137.261

Adustochaete yunnanensis sp. nov. from China

Yi-Fei Li[1,3] & Chang-Lin Zhao[1,2,3,4*]

[1] *Yunnan Key Laboratory of Plateau Wetland Conservation, Restoration and Ecological Services,*
[2] *Key Laboratory for Forest Resources Conservation and Utilization in the Southwest Mountains of China, Ministry of Education,* and [3] *College of Biodiversity Conservation, Southwest Forestry University, Kunming 650224, P.R. China*
[4] *Yunnan Key Laboratory for Fungal Diversity and Green Development, Kunming Institute of Botany, Chinese Academy of Science, Kunming 650201, China*

[*] Correspondence to: *fungi@swfu.edu.cn*

Abstract—A new wood-rotting fungal species, *Adustochaete yunnanensis*, is described from China on the basis of morphological and molecular data. The new fungus is characterized by annual, resupinate basidiomata with a grandinioid hymenial surface, encrusted hyphidia, and narrow cylindrical to allantoid basidiospores. ITS and nLSU rRNA sequences were generated from samples and analyzed phylogenetically using Maximum Likelihood, Maximum Parsimony, and Bayesian Inference methods. The phylogeny clustered *A. yunnanensis* within *Adustochaete*, where it formed a well-supported independent lineage sister to a clade comprising *A. interrupta* and *A. rava*. An identification key to *Adustochaete* species is provided.

Key words—*Auriculariaceae, Auriculariales, Basidiomycota*, taxonomy, Yunnan Province

Introduction

The wood-rotting fungal genus *Adustochaete* Alvarenga & K.H. Larss., typified by *A. rava* Alvarenga & K.H. Larss., is characterized by small dry soft resupinate grayish to brownish basidiomata with spiny or tuberculate hymenophore; a monomitic hyphal system of generative hyphae with clamp connections; the presence of hyphidia and cystidia; basidia that are ellipsoid-ovoid to obconical, longitudinally septate, 4-celled, and occasionally tapering

to the stalk-like base; and hyaline, thin-walled, cylindrical to broadly cylindrical, straight or curved basidiospores containing oil droplets in the cytoplasm (Alvarenga & al. 2019). *Adustochaete* species are primarily wood decomposers, causing white-rot of angiosperms (Alvarenga & al. 2019) with characters similar to other white-rot fungi (Ma & al. 2019, Zhao & Ma 2019, Chen & al. 2020, Huang & al. 2020, Peng & Zhao 2020). Presently three species are accepted in this genus (Alvarenga & al. 2019, Hyde & al. 2020).

Alvarenga & al. (2019), who conducted comprehensive phylogenetic research on *Heterochaete* sensu lato (*Auriculariales*, *Basidiomycota*), proposed a new genus *Adustochaete*, which formed a single clade and grouped with *Eichleriella* Bres. and *Proterochaete* Spirin & V. Malysheva. The rDNA sequence analyses by Hyde & al. (2020) of all three *Adustochaete* species grouped *A. interrupta* Spirin & V. Malysheva, *A. nivea* Alvarenga, and *A. rava* in a single clade among clades of twelve other genera within *Auriculariaceae.*

During the investigations on wood-rotting fungi in southern China, an undescribed taxon was encountered. Analyses of the morphology and internal transcribed spacer (ITS) and large subunit nuclear ribosomal RNA gene (nLSU) sequences placed the unknown taxon in *Adustochaete*, where it is proposed here as a new species, *A. yunnanensis*.

Table 1. Species, specimens, and sequences used in this study (new sequences in bold).

Species	Sample	GenBank accession no.		Reference
		ITS	nLSU	
Adustochaete interrupta	LR 23435	MK391518	MK391527	Alvarenga & al. 2019
A. rava	RC 841	MK391516	—	Alvarenga & al. 2019
	KHL 15526	MK391517	MK391526	Alvarenga & al. 2019
A. yunnanensis	**CLZhao 8212 [T]**	MZ911964	MZ950629	Present study
	CLZhao 4671	MZ911965	—	Present study
	CLZhao 4401	MZ911966	MZ950630	Present study
Amphistereum leveilleanum	LentzFP 106715	KX262119	KX262168	Malysheva & Spirin 2017
A. schrenkii	Burdsall 8476	KX262130	KX262178	Malysheva & Spirin 2017
Aporpium caryae	Miettinen 14774	JX044145	JX044145	Miettinen & al. 2012
	WD 2207	AB871751	AB871730	Sotome & al. 2014
Auricularia mesenterica	Oberwinkler 25132	AF291271	AF291292	Wei & Oberwinkler 2001

A. polytricha	TUFC 12920	AB871752	AB871733	Sotome & al. 2014
Bourdotia galzinii	Miettinen 15900.4	MG757511	MG757511	Spirin & al. 2019
Ductifera sucina	Wells 2155	AY509551	AY509551	Spirin & al. 2019
Eichleriella crocata	TAAM 101077	KX262100	KX262147	Malysheva & Spirin 2017
E. tenuicula	ValCB 1	MK391515	MK391525	Alvarenga & al. 2019
Elmerina cladophora	Miettinen 14314	MG757509	MG757509	Spirin & al. 2019
E. sclerodontia	Miettinen 16431	MG757512	MG757512	Spirin & al. 2019
Exidia glandulosa	YC Dai 21232	MT663362	MT664781	Wu & al. 2020
	YC Dai 21233	MT663363	MT664782	Wu & al. 2020
Grammatus labyrinthinus	Yuan 1759	KM379137	KM379138	Alvarenga & al. 2019
	Yuan 1600	KM379139	KM379140	Alvarenga & al. 2019
Heterochaetella brachyspora	RJB 13295	AY509552	AY509552	Alvarenga & al. 2019
Heteroradulum kmetii	Ginns 2529	KX262135	KX262183	Malysheva & Spirin 2017
	Spirin 6466	KX262104	KX262152	Malysheva & Spirin 2017
Hyalodon piceicola	Spirin 2689	MG735414	MG735422	Spirin & al. 2019
	Spirin 11063	MG735415	MG735423	Spirin & al. 2019
Proterochaete adusta	CNOM 10519	MK391519	—	Alvarenga & al. 2019
	VS 9021	MK391520	MK391528	Alvarenga & al. 2019
Protodaedalea foliacea	Miettinen 13054	MG757507	MG757507	Spirin & al. 2019
Protodontia subgelatinosa	voucher 11079	MG735412	MG735420	Spirin & al. 2019
Protohydnum cartilagineum	SP 467240	MG735426	MG735419	Spirin & al. 2019
Protomerulius subreflexus	X 1593	MG757508	MG757508	Spirin & al. 2019
Pseudohydnum gelatinosum	—	AF384861	AF384861	Alvarenga & al. 2019
	AFTOL-ID 1875	DQ520094	DQ520094	Alvarenga & al. 2019
Sclerotrema griseobrunnea	Spirin 7674	KX262140	KX857818	Malysheva & Spirin 2017
	Niemelä 2722	KX262144	KX262192	Malysheva & Spirin 2017
Sistotrema brinkmannii	isolate 236	JX535169	JX535170	Grum-Grzhimaylo & al. 2018
Stypella vermiformis	Spirin 11330	MG735417	MG735425	Spirin & al. 2019
	OF 188059	MG735418	—	Spirin & al. 2019
Tremellochaete japonica	LE 303446	KX262110	KX262160	Malysheva & Spirin 2017
	TAA 42689	AF291274	AF291320	Wei & Oberwinkler 2001
Tremiscus helvelloides	AFTOL-ID 1680	DQ520100	DQ520100	Alvarenga & al. 2019

Materials & methods

The studied specimens have been deposited at the herbarium of Southwest Forestry University, Kunming, Yunnan Province, P.R. China (SWFC). Macromorphological descriptions are based on field notes. Colour terms follow Petersen (1996). The dried specimens were observed under a light microscope following Dai (2012). The following abbreviations are used: KOH = 5% potassium hydroxide, CB = Cotton Blue, CB– = acyanophilous, IKI = Melzer's reagent, IKI– = both non-amyloid and non-dextrinoid, L = mean spore length (arithmetic average of all spores), W = mean spore width (arithmetic average of all spores), Q = variation in the L/W ratios among specimens, and n = number of spores measured/number of specimens.

Genomic DNA was obtained from dried specimens using a CTAB rapid plant genome extraction kit-DN14 (Aidlab Biotechnologies Co., Ltd) following the manufacturer's instructions. The ITS region was amplified with primer pairs ITS5 and ITS4 (White & al. 1990), and the nLSU region was amplified with primer pairs LR0R and LR7 (http://lutzonilab.org/nuclear-ribosomal-dna). The PCR procedure for ITS was initial denaturation at 95 °C for 3 min, followed by 35 cycles at 94 °C for 40 s, 58 °C for 45 s, and 72 °C for 1 min, and a final extension of 72 °C for 10 min. The PCR procedure for nLSU was initial denaturation at 94 °C for 1 min, followed by 35 cycles at 94 °C for 30 s, 48 °C for 1 min, and 72 °C for 1.5 min, and a final extension of 72 °C for 10 min. The PCR products were purified and directly sequenced at Kunming Tsingke Biological Technology Limited Company (P.R. China). All newly generated sequences were deposited at GenBank (Table 1).

Sequencher 4.6 (GeneCodes) was used to edit the DNA sequences. Sequences were aligned in MAFFT v. 7 (https://mafft.cbrc.jp/alignment/server/) using the "G-INS-I" strategy and manually adjusted in BioEdit (Hall 1999). The sequence alignment was deposited in TreeBase (submission ID 28753). *Sistotrema brinkmannii* (Bres.) J. Erikss. was used as outgroup to root tree following Alvarenga & al. (2019) in the ITS+nLSU analyses (Fig. 1).

Maximum Parsimony (MP) analysis was applied to the ITS+nLSU dataset sequences. Approaches to phylogenetic analysis followed Zhao & Wu (2017), and the tree construction procedure was performed in PAUP* version 4.0b10 (Swofford 2002). All characters were equally weighted and gaps were treated as missing data. Trees were inferred using the heuristic search option with TBR branch swapping and 1000 random sequence additions. Max-trees were set to 5000, branches of zero length were collapsed and all parsimonious trees were saved. Clade robustness was assessed using a bootstrap (BT) analysis with 1000 replicates (Felsenstein 1985). Descriptive tree statistics tree length (TL), consistency index (CI), retention index (RI), rescaled consistency index (RC), and homoplasy index (HI) were calculated for each MP Tree generated. Sequences were also analyzed using Maximum Likelihood (ML) with RAxML-HPC2 through the Cipres Science Gateway (www.phylo.org, Miller & al. 2009). Branch support (BS) for ML analysis was determined by 1000 bootstrap replicates.

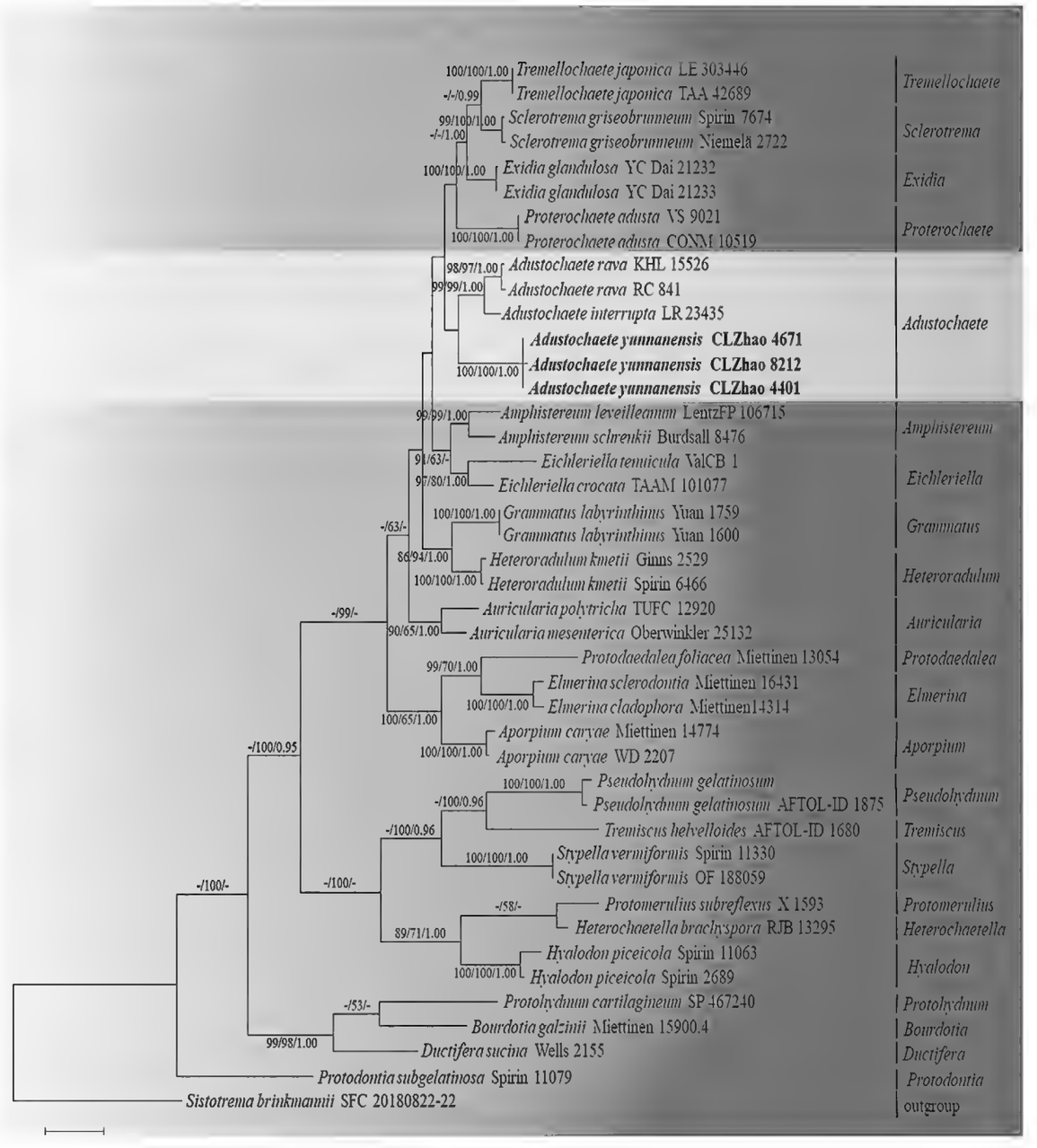


Fig. 1. Maximum parsimony strict consensus tree illustrating the phylogeny of *Adustochaete yunnanensis* and related genera in *Auriculariaceae*, based on ITS+nLSU sequences. Branches are labelled with maximum likelihood bootstrap values >70%, parsimony bootstrap values >50%, and Bayesian posterior probabilities >0.95.

MrModeltest 2.3 (Nylander 2004) was used to determine the best-fit evolution model for each data set for Bayesian Inference (BI). BI was calculated with MrBayes 3.1.2 with a general time reversible (GTR+I+G) model of DNA substitution using a Bayesian Posterior Probabilities (BPP) and a gamma distribution rate variation across sites (Ronquist & Huelsenbeck 2003). Four Markov chains run for 2 runs from random starting trees for 460 thousand generations and trees were sampled every 100 generations. The first one-fourth generations were discarded as burn-in.

A majority rule consensus tree of all remaining trees was calculated. Branches were considered as significantly supported if they received BS >70%, BT >50%, or BPP >0.95.

Molecular phylogeny

The ITS+nLSU dataset (Fig. 1) included sequences from 43 fungal specimens representing 30 taxa. The dataset had an aligned length of 2802 characters, of which 1260 characters were constant, 205 parsimony-uninformative, and 526 parsimony-informative. MP analysis yielded 1 equally parsimonious tree (TL = 280, CI = 0.440, HI = 0.560, RI = 0.533, RC = 0.234). The best-fit model for ITS+nLSU alignment estimated and applied in the BI was GTR+I+G, lset nst = 6, rates = invgamma; prset statefreqpr = dirichlet (1,1,1,1). BI produced a similar topology with an average standard deviation of split frequencies = 0.009507.

The phylogenetic tree inferred from ITS+nLSU sequences includes three *Adustochaete* species. The new taxon, *A. yunnanensis*, formed a well-supported lineage and was sister to a clade comprising *A. interrupta* and *A. rava* with lower support.

Taxonomy

Adustochaete yunnanensis C.L. Zhao, **sp. nov.** Figs 2, 3

MB 841453

Differs from *Adustochaete interrupta* by its grandinioid hymenial surface and larger basidiospores.

Holotype: China. Yunnan Province: Yuxi, Xingping County, Tea Horse Ancient Road spot, on the fallen angiosperm branch, 21 Aug 2018, CLZhao 8212 (**Holotype**, SWFC 008212; GenBank MZ911964, MZ950629).

Etymology: *yunnanensis* (Lat.) refers to the province locality of the type specimen.

Basidiomata annual, resupinate, soft, waxy, without odor or taste when fresh, becoming hard membranous on drying, ≤7 × 3 cm (length × breadth), ≤200 μm thick. Hymenial surface grandinioid, aculei 4–9 per mm, 40–135 μm long, grayish to pale brownish when fresh, turning dark grayish to brownish upon drying. Margin sterile, grayish, ≤1 mm wide.

Hyphal structure monomitic; hyphae generative, clamped, hyaline, more or less interwoven, thin-walled, frequently branched, 2–3 μm in diameter; IKI–, CB–; tissues unchanged in KOH.

Hymenium cystidia numerous, clavate to fusiform, hyaline, thin-walled, smooth, 17.5–24.5 × 3.5–5.8 μm, cystidioles absent; hyphidia abundant, variably branched, hyaline, thin-walled, encrusted with crystals at the apex, 19.5–30 × 4.5–8 μm; basidia narrowly ovoid to obconical, 4-celled, occasionally bearing an enucleate stalk, 25–47.5 × 8.5–14 μm; basidioles dominant, in shape similar to basidia, but slightly smaller.

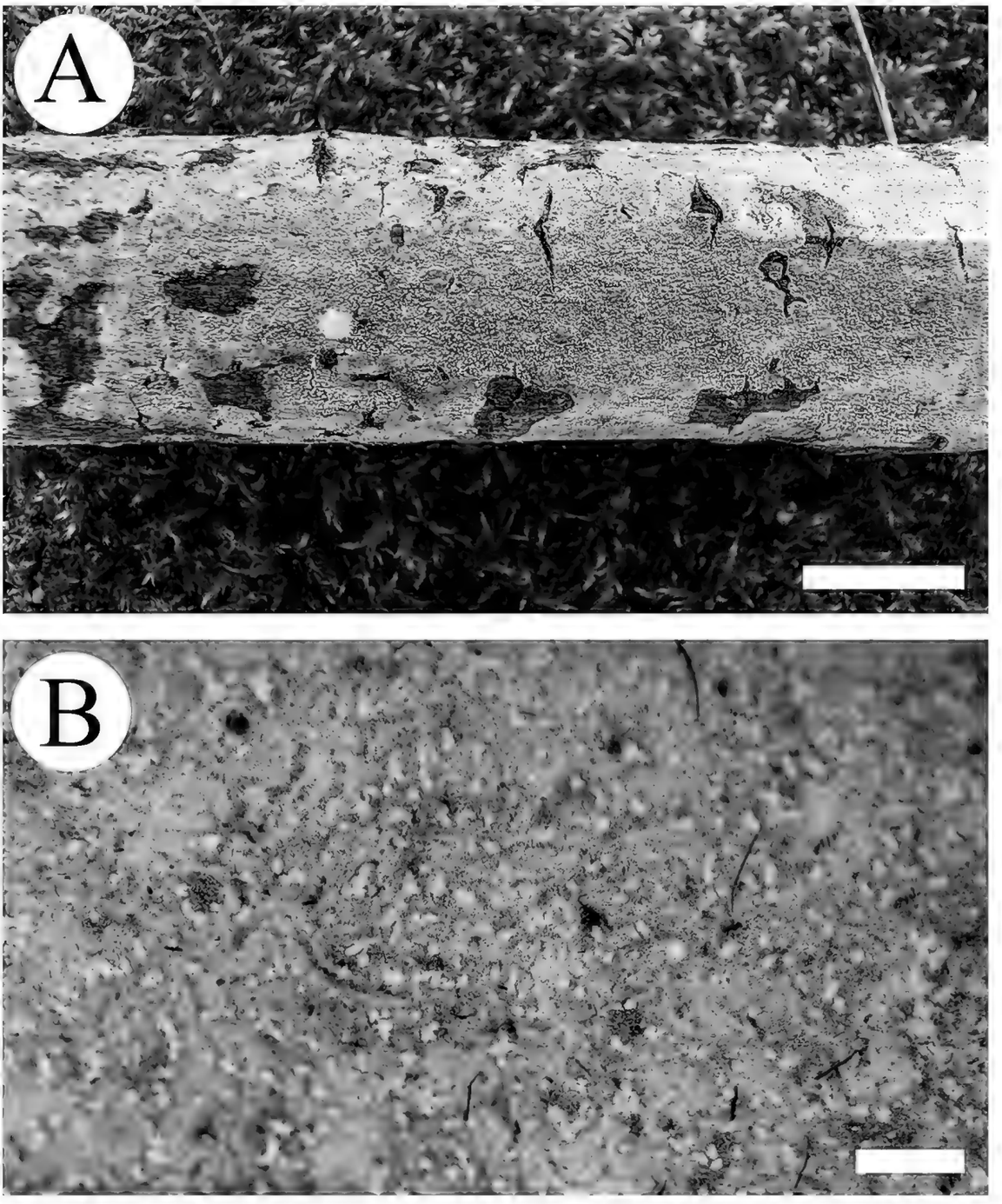


Fig. 2. *Adustochaete yunnanensis* (holotype, SWFC 008212).
A. Habit; B. Characteristic hymenophore. Scale bars A = 1 cm; B = 1 mm.

Basidiospores narrow cylindrical to allantoid, slightly to distinctly curved, hyaline, thin-walled, smooth, with oil droplets in the cytoplasm, IKI–, CB–, (11–)12–20(–21) × (4.5–)5–7(–7.5) μm, L = 15.5 μm, W = 5.7 μm, Q = 2.48–2.98 (n = 90/3).

Type of rot: white rot.

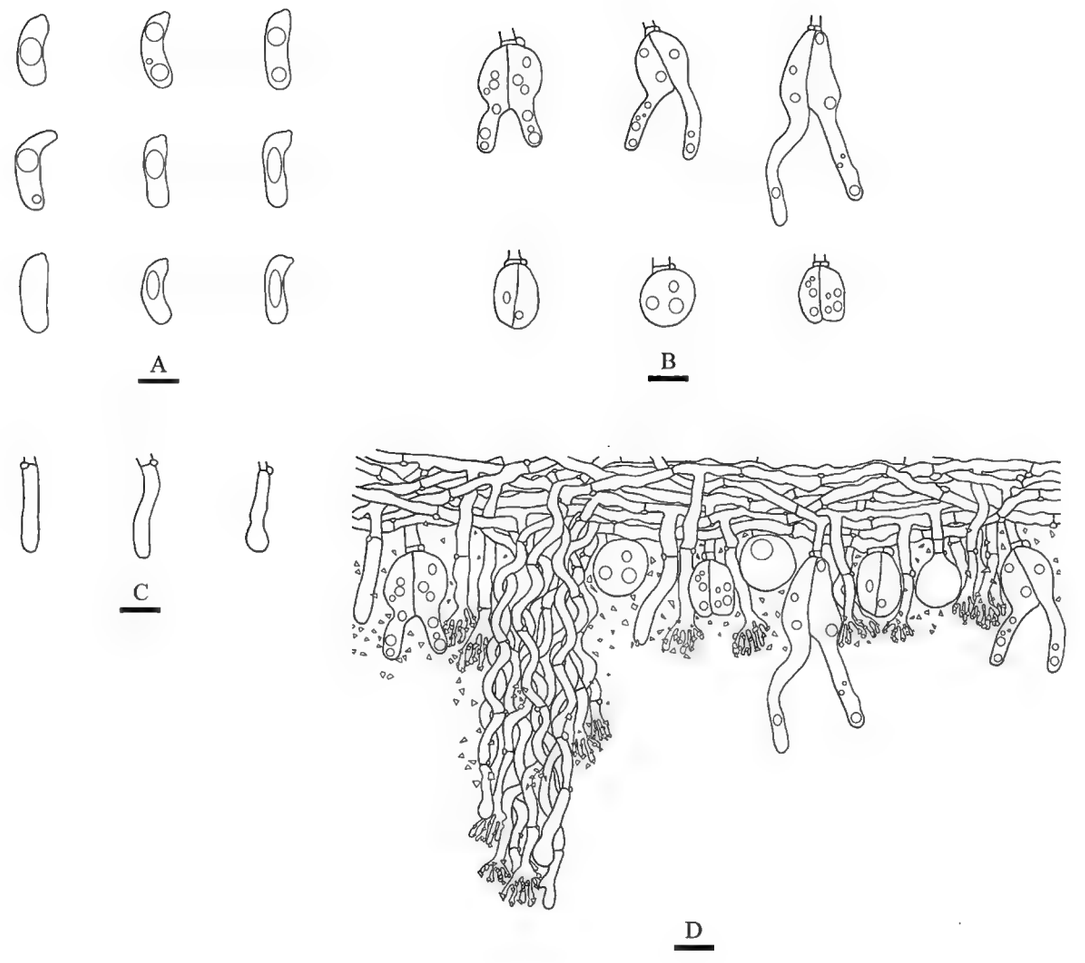


Fig. 3. *Adustochaete yunnanensis* (ex holotype, SWFC 008212).
A. Basidiospores; B. Basidia and basidioles; C. Cystidia; D. Section of hymenium.
Scale bars = 10 μm.

Additional specimens examined: **CHINA. Yunnan province. Puer:** Jingdong County, Wuliangshan National Nature Reserve, on a thick angiosperm branch, 6 Oct 2017, CLZhao 4671 (SWFC 004671; GenBank MZ911965); CLZhao 4401 (SWFC 004401; GenBank MZ911966, MZ950630).

Discussion

The previous morphological and molecular analyses by Alvarenga & al. (2019) strongly supported *Adustochaete* as an independent genus. In our ITS and nLSU sequence analyses, *A. yunnanensis* formed a well-supported monophyletic lineage sister to the *A. interrupta* + *A. rava* clade.

Adustochaete interrupta differs morphologically from *A. yunnanensis* in its light ochraceous-gray to brownish hymenophore, smaller basidia (15.1–24 ×

9.1–11.8 µm), and larger cystidia (45–96 × 6–13.5 µm, Alvarenga & al. 2019), and *A. rava* differs in its white, arachnoid to fimbriate margin, shorter basidia (10.8–15.2 × 7.3–10 µm), and longer cystidia (27–52 × 4–8 µm, Alvarenga & al. 2019). *Adustochaete nivea* differs from *A. yunnanensis* by having a white hymenial surface, smaller basidia (14.9–16.2 × 9.7–10.1 µm), and absence of cystidia (Hyde & al. 2020).

This the first report of an *Adustochaete* species in China (Wu & al. 2020).

Key to the four accepted species of *Adustochaete* worldwide

1. Cystidia absent ..... *A. nivea*
1. Cystidia present 2
2. Cystidia >25 µm long, basidia <24 µm long 3
2. Cystidia <25 µm long, basidia >24 µm long ..... *A. yunnanensis*
3. Basidia <15 µm long, basidiospores <5µm wide ..... *A. rava*
3. Basidia >15 µm long, basidiospores >5µm wide ..... *A. interrupta*

Acknowledgments

Special thanks are due to Drs. Mei-Ling Han (Langfang Normal University, Hebei, P.R. China) and Sana Jabeen (University of Education, Lahore, Pakistan) for expert presubmission review. The research was supported by the National Natural Science Foundation of China (Project No. 32170004), Yunnan Fundamental Research Project (Grant No. 202001AS070043), the High-level Talents Program of Yunnan Province (YNQRQNRC-2018-111), Yunnan Key Laboratory of Plateau Wetland Conservation, Restoration and Ecological Services (202105AG070002), and Science and Technology Innovation Project of Southwest Forestry University (KY21017).

Literature cited

Alvarenga RLM, Spirin V, Malysheva V, Gibertoni TB, Larsson KH. 2019. Two new genera and six other novelties in *Heterochaete* sensu lato (*Auriculariales*, *Basidiomycota*). Botany 97: 439–451. https://doi.org/10.1139/cjb-2019-0046

Chen JZ, Yang X, Zhao CL. 2020. *Vanderbylia cinnamomea* sp. nov. from southwestern China. Mycotaxon 135: 371–382. https://doi.org/10.5248/135.371

Dai YC. 2012. Polypore diversity in China with an annotated checklist of Chinese polypores. Mycoscience 53: 49–80. https://doi.org/10.1007/s10267-011-0134-3

Felsenstein J. 1985. Confidence intervals on phylogenetics: an approach using bootstrap. Evolution 39: 783–791. https://doi.org/10.1111/j.1558-5646.1985.tb00420.x

Grum-Grzhimaylo OA, Debets AJM, Bilanenko EN. 2018. Mosaic structure of the fungal community in the Kislo-Sladkoe Lake that is detaching from the White Sea. Polar Biology 41: 2075–2089. https://doi.org/10.1007/s00300-018-2347-9

Hall TA. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids Symposium Series 41: 95–98. https://doi.org/10.1021/bk-1999-0734.ch008

Huang RX, Luo KY, Ma RX, Zhao CL. 2020. Morphological and molecular identification of *Phlebia wuliangshanensis* sp. nov. in China. Mycotaxon 135: 103–117. https://doi.org/10.5248/135.103

Hyde KD, Dong Y, Phookamsak R, Jeewon R, Bhat DJ, Jones EBG, Liu NG & al. 2020. Fungal diversity notes 1151–1276: taxonomic and phylogenetic contributions on genera and species of fungal taxa. Fungal Diversity 100: 5–277. https://doi.org/10.1007/s13225-020-00439-5

Ma RL, Gao M, Zhuang XL, Zhao CL. 2019. *Septobasidium aquilariae* sp. nov. from China. Mycotaxon 134: 517–528. https://doi.org/10.5248/134.517

Malysheva V, Spirin V. 2017. Taxonomy and phylogeny of the *Auriculariales* (*Agaricomycetes*, *Basidiomycota*) with stereoid basidiocarps. Fungal Biology 121: 689–715. https://doi.org/10.1016/j.funbio.2017.05.001

Miettinen O, Spirin V, Niemelä T. 2012. Notes on the genus *Aporpium* (*Auriculariales*, *Basidiomycota*), with a new species from temperate Europe. Annales Botanici Fennici 49: 359–368. https://doi.org/10.5735/085.049.0607

Miller MA, Holder MT, Vos R, Midford PE, Liebowitz T, Chan L, Hoover P, Warnow T. 2009. The CIPRES Portals. CIPRES url: http://www.phylo.org/sub_sections/portal. 2009-08-04. (Archived by WebCite® at https://www.webcitation.org/5imQlJeQa).

Nylander JAA. 2004. MrModeltest v2. Program distributed by the author. Evolutionary Biology Centre, Uppsala University, Uppsala.

Peng JH, Zhao CL. 2020. *Armillaria xiaocaobaensis* sp. nov. from China. Mycotaxon 135: 431–441. https://doi.org/10.5248/135.431

Ronquist F, Huelsenbeck JP. 2003. MrBayes 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19: 1572–1574. https://doi.org/10.1093/bioinformatics/btg180

Sotome K, Maekawa N, Nakagiri A, Lee SS, Hattori T. 2014. Taxonomic study of Asian species of poroid *Auriculariales*. Mycological Progress 13: 987–997. https://doi.org/10.1007/s11557-014-0984-0

Spirin V, Malysheva V, Miettinen O, Vlasák J, Alvarenga RLM, Gibertoni TB, Ryvarden L, Larsson KH. 2019. On *Protomerulius* and *Heterochaetella* (*Auriculariales*, *Basidiomycota*). Mycological Progress 18: 1079–1099. https://doi.org/10.1007/s11557-019-01507-0

Swofford DL. 2002. PAUP*: phylogenetic analysis using parsimony (*and other methods). Version 4.0b10. Massachusetts: Sinauer Associates.

Wei M, Oberwinkler F. 2001. Phylogenetic relationships in *Auriculariales* and related groups – hypotheses derived from nuclear ribosomal DNA sequences. Mycological Research 105: 403–415. https://doi.org/10.1017/S095375620100363X

White TJ, Bruns TD, Lee SB, Taylor JW. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. 315–322, in: MA Innis & al. (eds). PCR protocols: a guide to methods and applications. Academic Press, New York. https://doi.org/10.1016/B978-0-12-372180-8.50042-1

Wu F, Zhao Q, Yang ZL, Ye SY, Rivoire B, Dai YC. 2020. *Exidia yadongensis*, a new edible species from East Asia. Mycosystema 39: 1203–1214. https://doi.org/10.13346/j.mycosystema.200205

Zhao CL, Ma X. 2019. *Perenniporia mopanshanensis* sp. nov. from China. Mycotaxon 134: 125–137. https://doi.org/10.5248/134.125

Zhao CL, Wu ZQ. 2017. *Ceriporiopsis kunmingensis* sp. nov. (*Polyporales*, *Basidiomycota*) evidenced by morphological characters and phylogenetic analysis. Mycological Progress 16: 93–100. https://doi.org/10.1007/s11557-016-1259-8

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 271-282

https://doi.org/10.5248/137.271

Erysiphe iranica sp. nov. on *Onobrychis caput-galli* in Iran

Hamideh Darsaraei [1], Mahdi Pirnia [2],
Seyed Akbar Khodaparast [1*], Seyed Yusef Behrooz [2]

[1] *University of Guilan, Department of Plant Protection, Faculty of Agricultural Sciences, Rasht, Iran*

[2] *University of Zabol, Department of Plant Protection, Faculty of Agriculture, Zabol, Iran*

* Correspondence to: *blumeria2015@gmail.com*

Abstract—In April 2014, powdery mildew symptoms were found on *Onobrychis caput-galli* in Khan Ahmad, Gachsaran, Iran. Morphological characters and analysis of ITS and 28S rDNA sequences revealed that this powdery mildew does not match previously recorded species on fabaceous hosts. It is proposed as a new species, *Erysiphe iranica,* and is described and illustrated, and compared with previous species of powdery mildew recorded on *Fabaceae.*

Key words—biodiversity, *Erysiphaceae*, *Helotiales*, sainfoin, taxonomic novelty

Introduction

Species of *Onobrychis* Mill., also known as sainfoins, are Eurasian perennial herbs of the legume family (*Fabaceae*). This genus includes more than 130 accepted species and is the second largest genus in the tribe *Hedysareae* (Amirahmadi & al. 2016). The main center of diversity of sainfoins extends from Central Asia to Iran with 77 species of *Onobrychis* distributed throughout Iran (Amirahmadi & al. 2016). Based on the literature, at least 27 of these 77 species are endemic to Iran (Muzaffariyān 1996). East Azarbaijan province has the highest level of cultivation and amount of sainfoin forage production in Iran. Moreover, several species grow as wild plant throughout

the country. The nutritional benefits of *Onobrychis* spp. are almost the same as alfalfa. This forage is easily digested and does not cause bloating in animals (Gholami & al. 2017).

Forty-two species of *Erysiphe* sect. *Erysiphe* and *E.* sect. *Microsphaera* have been reported from *Fabaceae*, of which several species represent taxonomically complicated groups (Braun & al. 2010, Braun & Cook 2012, Bradshaw & al. 2021). The existence of intermediate morphological features among morphologically allied species, such as *E. baptisiicola* U. Braun, *E. bremeri* U. Braun, *E. viciae-unijugae* (Homma) U. Braun, *E. pisi* DC., and *E. trifoliorum* (Wallr.) U. Braun, may sometimes cast doubt upon correct identifications of the taxa involved. Most of these taxa have overlapping host ranges as well. Recently rDNA-ITS sequencing has addressed some of these questions (Kiss & al. 2020, Takamatsu & al. 2002, Meeboon & Takamatsu 2017, Bradshaw & al. 2021). Bradshaw & al. (2021) conducted a phylogenetic analysis on *Erysiphe* species colonizing hosts of the fabaceous genus *Lupinus*, using sequences from ITS and 28S rDNA genomic regions. They included several powdery mildew species infecting fabaceous plants. Although they could find solutions for some *Erysiphe* species on *Fabaceae*, the *E. trifoliorum* complex remained unresolved. Hence, ITS sequencing is not always sufficient, so that combinations of sequence data, and morphological and host range characteristics are necessary for correct identification. Moreover, multi-gene sequencing is underway for better understanding of taxonomically difficult complexes of powdery mildew fungi (Ellingham & al. 2019, Qiu & al. 2020). Hence, multi-locus sequencing is another tool that can be used to answer taxonomically complicated issues in this group of powdery mildews. There are only three species recorded on *Onobrychis* spp.: *Erysiphe astragali* DC., *E. pisi*, and *E. trifoliorum* (Braun & Cook 2012). The two latter species have been recorded on *O. caput-galli* from Iran (Azadbakht & al. 2013). In this study, *Erysiphe iranica* is introduced as a new species on *O. caput-galli* based on morphological as well as phylogenetic peculiarities.

Materials & methods

Morphological examination

Chasmothecia on infected leaves were analyzed using a needle, and asexual morphs using a clear adhesive tape. The asexual morphs were transferred into a drop of 1:1 lactic acid and glycerin on a microscopic slide, slightly heated, and then examined with a Sairan BM22 biological microscope. Asci, ascospores, and chasmothecial appendages were examined on a microscopic slide containing a drop of water. At least 20 chasmothecia, appendages, asci, ascospores, conidiophores, and conidia were

Table 1. Sequences of *Erysiphe* species and related taxa used in the analyses.

Species name	Voucher	Host	Location	ITS	LSU
Erysiphe astragali	HAL3356F (Epitype)	*Astragalus glycyphyllus*	Germany	MZ265151	MZ265151
	HAL3358F	*Astragalus glycyphyllus*	Germany	MZ265150	MZ265150
	MUMH:2585	*Astragalus glycyphyllus*	Ukraine	LC010052	LC010052
	MUMH:2590	*Astragalus glycyphyllus*	Ukraine	LC010055	LC010055
Erysiphe baeumleri	HAL3360F (Epitype)	*Vicia sylvatica*	Germany	MZ265152	—
	HAL3354F	*Vicia cracca*	Germany	MZ265153	MZ265153
	HAL3355F	*Vicia cassubica*	Germany	MZ265154	MZ265154
	HAL3357F	*Vicia sylvatica*	Germany	MZ265155	MZ265155
Erysiphe bremeri	IRAN 10810F	*Alhagi* sp.	Iran	AB104463	AB103077
Erysiphe diffusa	MUMH:3121	*Desmodium incanum*	Argentina	LC010060	—
	A.M.R. Almeida OILal	*Lupinus albus*	Brazil	EF196666	—
Erysiphe fallax	MUMH:4972	*Carica papaya*	Mexico	LC228608	LC228608
	FL-1	*Macroptilium lathyroides*	USA	MH560056	MH560056
Erysiphe glycines	MUMHJPN: 0396	*Desmodium laxum*	Japan	LC009948	LC009947
	HMNWAFU-CF2012031	*Vicia gigantean*	China	KR048063	KR048126
Erysiphe glycines var. *glycines*	MUMH1462	*Glycine max*	Japan	AB078807	AB078806
Erysiphe guarinonii	HAL 2337 F	*Baptisia australis*	Germany	MT524083	—
	MUMHJPN:1425	*Laburnum alpinum*	Switzerland	LC009983	—
	WTU-F-072448	*Baptisia australis*	USA	MT516325	—
Erysiphe intermedia	HAL3381F (Epitype)	*Lupinus polyphyllus*	USA	MZ265161	—
	HAL3385F	*Lupinus polyphyllus*	USA	MZ265162	—
	HAL3384F	*Lupinus rivularis*	USA	MZ265165	—
	HAL3389F	*Lupinus latifolius*	USA	MZ265167	—
	OE2015PMCS297	*Lupinus* sp.	UK	KY660904	—
Erysiphe iranica	**GUM 1805 (holotype)**	***Onobrychis caput-galli***	**Iran**	**OL709413**	**OL709411**

Species name	Voucher	Host	Location	ITS	LSU
Erysiphe lespedezae	HMUT 7043	*Bauhinia purpurea*	China	MF066655	MF066659
	HMUT 7042	*Bauhinia purpurea*	China	MF066654	MF066658
	HMUT 7041	*Bauhinia blakeana*	China	MF066653	MF066657
	HMUT 7040	*Bauhinia blakeana*	China	MF066652	MF066656
	HMNWAFU-CF2010359	*Lespedeza floribunda*	China	KR048068	KR048130
Erysiphe longissima	HMJAU91780	*Caragana rosea*	China	MH371103	MH371104
	HMJAU91781	*Caragana rosea*	China	MH371105	MH371106
Erysiphe ludens	OE2016PMCS45	*Lathyrus pratensis*	UK	KY661116	—
	OE2015PMCS298	*Lathyrus odoratus*	UK	KY660905	—
Erysiphe lupini	HAL3379F	*Lupinus polyphyllus*	USA	MZ265168	—
	HAL3380F	*Lupinus lepidis*	USA	MZ265169	—
	HAL3378F (Holotype)	*Lupinus* sp.	USA	MZ265170	—
Erysiphe medicaginis	BRIP 70957	*Medicago polymorpha*	Australia	NR_171870	—
	IRAN 10803F	*Medicago sativa*	Iran	AB104519	AB102942
Erysiphe palczewskii	MUMHJPN:1085	*Robinia* × *slavinii*	Japan	LC009974	LC009973
	MUMHJPN:s0111	*Robinia pseudoacacia*	?	LC010083	LC010083
Erysiphe pisi	OE2014PM137CS	*Pisum* sp.	UK	KY660822	—
	?	*Lathyrus latifolius*	?	AF011306	—
	MUMH:1850	*Pisum sativum*	Thailand	LC163915	—
	DNA03	*Pisum sativum*	Japan	LC009890	—
	OE2016PMCS80	*Pisum sativum*	UK	KY653209	—
	OE2016PMCS65	*Pisum sativum*	UK	KY653208	—
	OE2016PMCS81	*Pisum sativum*	UK	KY653210	—
	HUPS-11	*Pisum sativum*	China	MH143492	—
	Gh-01	*Pisum sativum*	?	MH290560	—
Erysiphe rayssiae	MUMHJPN:1433	*Baptisia australis*	Netherlands	LC009988	—

Species name	Voucher	Host	Location	ITS	LSU
Erysiphe robiniae	QHU2019007	?	?	MT309809	MT420267
Erysiphe robiniae var. *chinensis*	QHU2016095	?	?	MT309808	MT420266
Erysiphe sesbaniae	GUM777	*Sesbania punicea*	Iran	MF663776	—
Erysiphe sp.	Oidio-RB EI4	*Erythrina indica*	Brazil	MF326645	—
	Oidio-RB EI3	*Erythrina indica*	Brazil	MF326644	—
	Oidio-RB EI2	*Erythrina indica*	Brazil	MF326643	—
	NAUJA	*Trigonella foenum-graecum*	India	KY695255	—
	KRM0022477	*Lupinus micranthus*	Portugal	MZ265171	—
Erysiphe thermopsidis	QHU2018034	?	?	MT309725	MT309801
Erysiphe trifoliorum	MUMH:0701	*Trifolium arvense*	Hungary	LC009955	LC009954
	MUMH:7031	*Trifolium pratense*	Azerbaijan	LC270858	—
	?	?	?	FJ378877	—
	GH 05	*Pisum sativum*	USA	FJ378874	—
	KUS-F28516	*Trifolium hybridum*	South Korea	MN216307	MT380914
	KUS-F28551	*Trifolium hybridum*	South Korea	MN216308	—
	EI 08-2	*Pisum sativum*	USA	GU361634	—
	EI 08-1	*Pisum sativum*	USA	GU361633	—
	HAL3363F	*Lupinus polyphyllus*	Germany	MZ265172	MZ265172
	MUMH:7038	*Medicago littoralis*	Azerbaijan	LC270860	LC270860
Erysiphe viciae-unijugae	MUMHJPN:1159	*Vicia bifolia*	Japan	LC009977	LC009976
	MUMHJPN:0817	*Vicia angustifolia*	Japan	LC009962	LC009961
	MUMH:7040	*Lathyrus odoratus*	Azerbaijan	LC270861	LC270861
Pseudoidium sp.	MUMH 2587	*Coronilla varia*	Ukraine	LC010054	—
	MUMH 4935	*Crotalaria* sp.	India	AB522715	—
	MUMH 4934	*Brassica pekinensis*	India	AB522714	—
	MUMH 89	*Sophora flavescens*	Japan	LC009919	LC009919
Phyllactinia moricola	MUMH923	*Morus* sp.	Iran	AB080561	AB080459

examined. All photos were taken using a Leica DM 100 microscope equipped with a digital camera. The holotype specimen is conserved in the fungarium of the University of Guilan, Rasht, Iran (GUM).

Molecular phylogeny

The whole DNA was extracted using Chelex 100 method (Walsh & al. 1991). Powdery mildew specific primers PM10 (5′-GGCCGGAAAGTTGTCCAAAC-3′)/ PM11 (5′-TACCGCTTCACTCGCCGTTA-3′) were used to amplify the rDNA-ITS region (Bradshaw & Tobin 2020). Primer pairs RPM2 (5′-ACCTCAGTAACGGCGAGTGA-3′) (Bradshaw & Tobin 2020) and NLP2 (5′-GGTCCCAACAGCTATGCTCT-3′) (Mori & al. 2000) were used for the amplification of the 28S. The amplicons were sent to Codon Genetic Group, Tehran, Iran, to be directly sequenced by a 3500 Genetic Analyzer (Applied Biosystems, USA) using the forward primers mentioned above. The sequences were submitted to NCBI under the accessions OL709413 (ITS)/OL709411 (LSU).

Afterwards, similar sequences were obtained from NCBI (Table 1) and aligned using MUSCLE (Edgar 2004) implemented in MEGA7 (Kumar & al. 2016). Alignments were further manually refined using the MEGA7 program. Phylogenetic trees were obtained from the data using the Maximum Likelihood (ML) method. *Phyllactinia moricola* (AB080561) was set as the outgroup taxa. The ML analysis was done using raxmlGUI (Silvestro & Michalak 2012), under a GTRGAMMA model. The bootstrap analysis (Felsenstein 1985) consists of 1000 pseudoreplicates followed by a search for the tree with the highest likelihood.

Taxonomy

Erysiphe iranica Darsaraei, Khodap. & Pirnia, sp. nov. Figs 1–3

MB 842174

Differs from *E. baptisiicola* by its shorter conidiophores with fewer cells following the foot-cell, fewer ascospores, and having hyaline appendages; and from *E. pisi* by its shorter conidiophores, conidia, and hyaline appendages.

Type: **Iran**, Kohkiluyeh & Boyerahmad province, Gachsaran, Khan Ahmad, on *Onobrychis caput-galli* (L.) Lam. (*Fabaceae*), 1 Apr. 2014, coll. Y. Behrooz (**Holotype**, GUM 1805)

Etymology: *iranica* refers to its origin in Iran.

Mycelium amphigenous, mostly hypophyllous, effuse. Hyphal cells 4–6 µm wide. Hyphal appressoria unlobed to lobed, solitary, rarely in opposite pairs. Conidiophores erect, arising centrally from the mother cell, 40–80 µm long. Foot-cells cylindrical, 32–40 × 6–13 µm, often sinuous at the basal part, followed by 1–2 shorter cells, forming conidia singly. Conidia ellipsoid, ovoid, cylindrical, occasionally adhering in false chains containing two conidia, 26–36 × 10–16 µm. Conidial germination terminal or sub-terminal. Germ tube

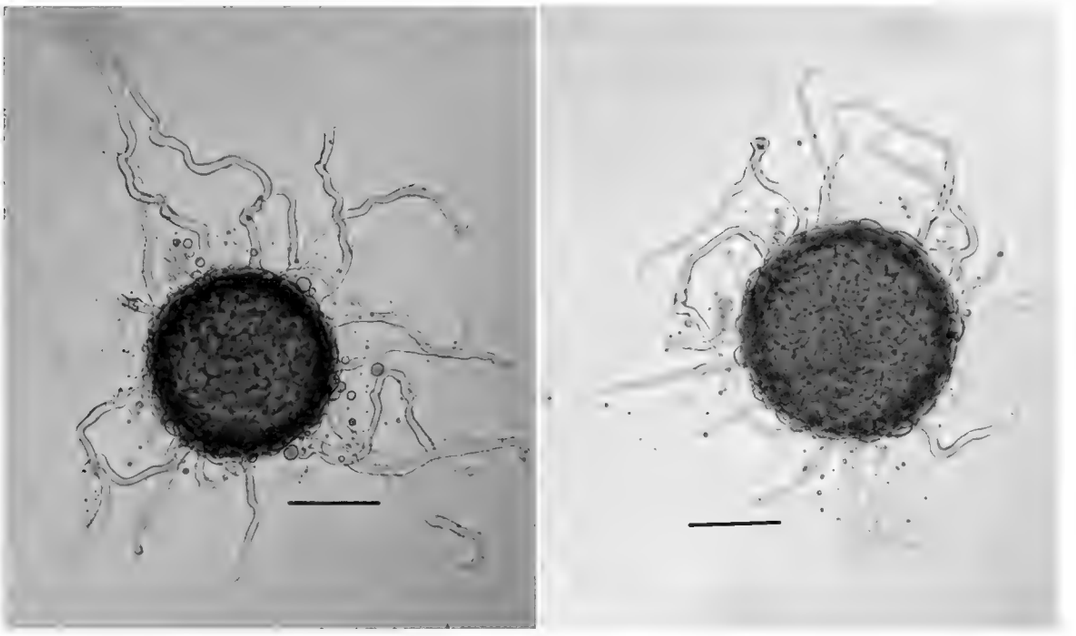


FIG. 1: *Erysiphe iranica* (holotype, GUM 1805). Chasmothecia. Scale bars = 50 µm.

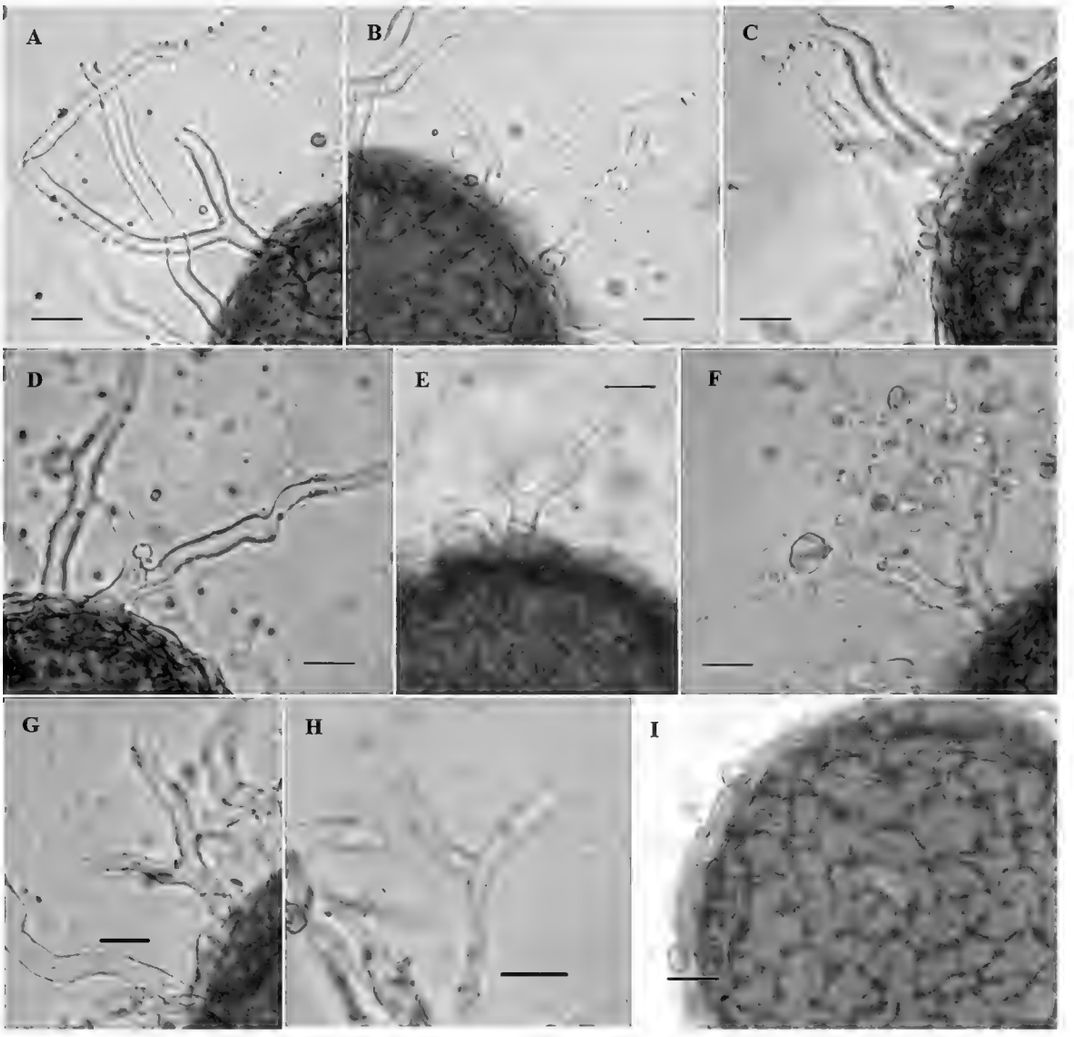


FIG. 2: *Erysiphe iranica* (holotype, GUM 1805).
A–H. Appendages; I. Peridium cells. Scale bars = 10 µm.

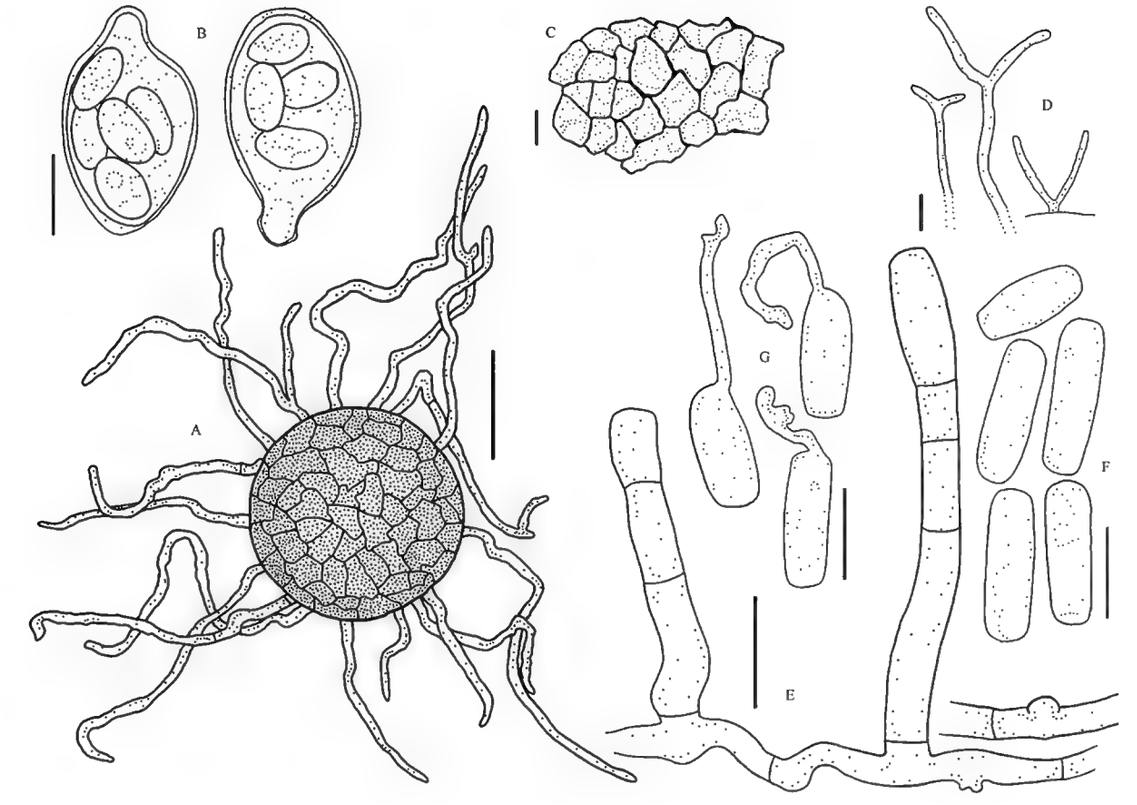
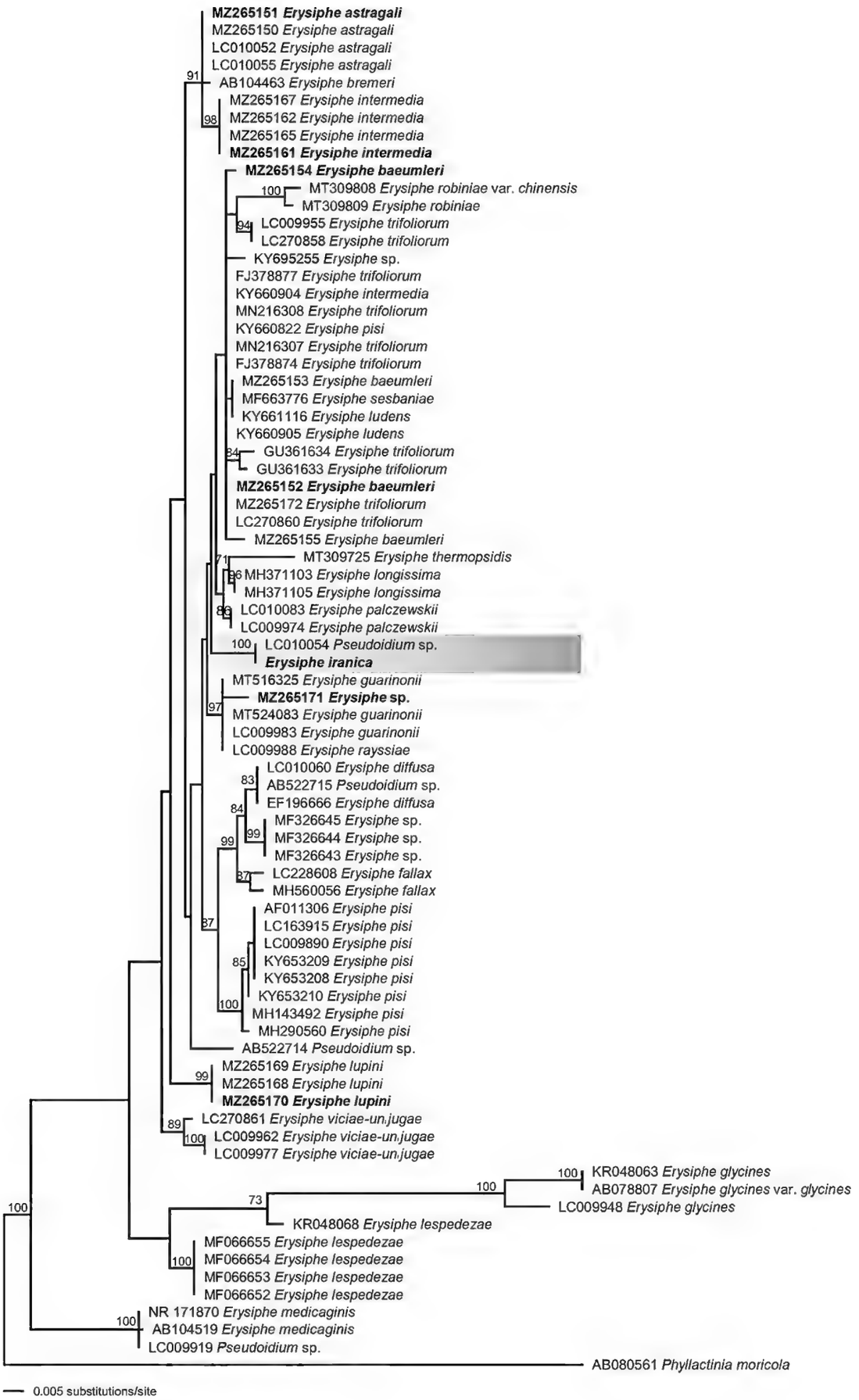


Fig. 3: *Erysiphe iranica* (holotype, GUM 1805). A. Chasmothecium; B. Asci; C. Peridium cells. D. Tips of appendages; E. Conidiophores and hyphal appressoria; F. Conidia; G. Conidial germ tubes. Scale bars: A = 50 µm; B, E-G = 20 µm; C, D = 10 µm.

up to 150 µm long. Chasmothecia amphigenous and caulicolous, scattered to ± gregarious, (85–)95–125 µm diam. Peridium cells conspicuous, irregularly polygonal, 8–25 µm diam. Appendages equatorial and somewhat in the lower half, hyaline, ~10–25, myceloid, occasionally slightly geniculate or angularly bent, sinuous, flexuous, occasionally forked, forming branches near the base or towards the tip, branchlets may be symmetric or not, occasionally with inconspicuous septa, about 0.5–2.5 times as long as the chasmothecial diam., width 12–20 µm at the very base, then 4–5 µm throughout, wall thin, almost equal throughout, smooth to ± rough. Asci 4–6, saccate-clavate, short-stalked to almost sessile, 48–67 × 27–38 µm, 3–5-spored. Ascospores ellipsoid, with oil drops, 15–23 × 8–13 µm, colorless or rather faintly yellow.

Fig. 4: Phylogenetic analysis of combined data of the 5′-end of the LSU rDNA and ITS region for 77 sequences from *Erysiphe* spp. on *Fabaceae*, including *Erysiphe iranica* and an outgroup sequence. BS values >70% by the maximum likelihood method are shown on the branches. Evolutionary analyses were conducted in raxmlGUI. Sequences from this study and from type materials are indicted by bold-face type.


MZ265151 Erysiphe astragali
MZ265150 Erysiphe astragali
LC010052 Erysiphe astragali
LC010055 Erysiphe astragali
AB104463 Erysiphe bremeri
MZ265167 Erysiphe intermedia
MZ265162 Erysiphe intermedia
MZ265165 Erysiphe intermedia
MZ265161 Erysiphe intermedia
MZ265154 Erysiphe baeumleri
MT309808 Erysiphe robiniae var. chinensis
MT309809 Erysiphe robiniae
LC009955 Erysiphe trifoliorum
LC270858 Erysiphe trifoliorum
KY695255 Erysiphe sp.
FJ378877 Erysiphe trifoliorum
KY660904 Erysiphe intermedia
MN216308 Erysiphe trifoliorum
KY660822 Erysiphe pisi
MN216307 Erysiphe trifoliorum
FJ378874 Erysiphe trifoliorum
MZ265153 Erysiphe baeumleri
MF663776 Erysiphe sesbaniae
KY661116 Erysiphe ludens
KY660905 Erysiphe ludens
GU361634 Erysiphe trifoliorum
GU361633 Erysiphe trifoliorum
MZ265152 Erysiphe baeumleri
MZ265172 Erysiphe trifoliorum
LC270860 Erysiphe trifoliorum
MZ265155 Erysiphe baeumleri
MT309725 Erysiphe thermopsidis
MH371103 Erysiphe longissima
MH371105 Erysiphe longissima
LC010083 Erysiphe palczewskii
LC009974 Erysiphe palczewskii
LC010054 Pseudoidium sp.
Erysiphe iranica
MT516325 Erysiphe guarinonii
MZ265171 Erysiphe sp.
MT524083 Erysiphe guarinonii
LC009983 Erysiphe guarinonii
LC009988 Erysiphe rayssiae
LC010060 Erysiphe diffusa
AB522715 Pseudoidium sp.
EF196666 Erysiphe diffusa
MF326645 Erysiphe sp.
MF326644 Erysiphe sp.
MF326643 Erysiphe sp.
LC228608 Erysiphe fallax
MH560056 Erysiphe fallax
AF011306 Erysiphe pisi
LC163915 Erysiphe pisi
LC009890 Erysiphe pisi
KY653209 Erysiphe pisi
KY653208 Erysiphe pisi
KY653210 Erysiphe pisi
MH143492 Erysiphe pisi
MH290560 Erysiphe pisi
AB522714 Pseudoidium sp.
MZ265169 Erysiphe lupini
MZ265168 Erysiphe lupini
MZ265170 Erysiphe lupini
LC270861 Erysiphe viciae-unijugae
LC009962 Erysiphe viciae-unijugae
LC009977 Erysiphe viciae-unijugae
KR048063 Erysiphe glycines
AB078807 Erysiphe glycines var. glycines
LC009948 Erysiphe glycines
KR048068 Erysiphe lespedezae
MF066655 Erysiphe lespedezae
MF066654 Erysiphe lespedezae
MF066653 Erysiphe lespedezae
MF066652 Erysiphe lespedezae
NR 171870 Erysiphe medicaginis
AB104519 Erysiphe medicaginis
LC009919 Pseudoidium sp.
AB080561 Phyllactinia moricola
0.005 substitutions/site

Discussion

Molecular phylogeny

A total of 78 sequences comprising 1224 characters were included in the phylogenetic analysis. *Erysiphe iranica* differed from a *Pseudoidium* sp. (MUMH 2587, LC010054) from Ukraine by only two bases (one substitution; one indel) in the ITS sequence, and by only one base (indel) in the 28S sequence. The next closest hit for the ITS sequence was *E. trifoliorum* (LC270860, identities 682/695, Abasova & al. 2018). We observed 19 substitutions in nucleotide sequences of *E. iranica* compared with another closely related species, *E. diffusa* (Cooke & Peck) U. Braun & S. Takam.

Erysiphe iranica and *Pseudoidium* sp. formed a distinct clade with 100% BS support (Fig. 4).

Morphology

Among the 42 *Erysiphe* species on *Fabaceae,* some (e.g., *E. trifoliorum* and *E. pisi*) are undoubtedly complexes of several taxa and are morphologically and genetically (according to the ITS sequence) almost indistinguishable. The rDNA ITS and 28S sequences from *E. iranica* are clearly separated from other available sequences retrieved from powdery mildew species on *Fabaceae*. The only sequence with greater than 99.6% identity with *E. iranica* on *Onobrychis* was *Pseudoidium* sp. (MUMH 2587) on *Securigera varia* [≡ *Coronilla varia*], but morphological data for this anamorphic specimen is unavailable. *Onobrychis* (*Fabaceae* tribe *Hedysareae*) and *Securigera* (*Fabaceae* tribe *Loteae*) are not closely allied, which suggests that *E. iranica* may have a wider host range within *Fabaceae.*

Erysiphe iranica is also morphologically distinct, with relatively few similar species. *Erysiphe baptisiicola* has longer conidiophores, more cells (1–3) above the foot-cell, more ascospores, and pigmented appendages that are thick and smooth to (usually) distinctly verruculose. *Erysiphe pisi* differs in its longer and pigmented appendages and longer conidiophores and conidia. We conclude that *E. iranica* on *Onobrychis caput-galli* from Iran is morphologically distinct from all previously described *Erysiphe* species on *Fabaceae*; and the combination of its morphological and molecular differences justifies its proposal as a new species.

Acknowledgments

The authors gratefully acknowledge Prof. Uwe Braun (Martin-Luther-Universität, Halle, Germany) and Prof. Hyeon-Dong Shin (Korea University, Seoul, Korea) for their very useful and thoughtful comments and serving as pre-submission reviewers.

This work was supported by a grant from the Iran National Science Foundation (INSF), No. 96007836 to S. A. Khodaparast.

Literature cited

Abasova LV, Aghayeva DN, Takamatsu S. 2018. Notes on powdery mildews of the genus *Erysiphe* from Azerbaijan. Current Research in Environmental and Applied Mycology 8: 30–53. https://doi.org/10.5943/cream/8/1/3

Amirahmadi A, Kazempour-Osaloo S, Kaveh A, Maassoumi AA, Naderi R. 2016. The phylogeny and new classification of the genus *Onobrychis* (*Fabaceae-Hedysareae*): evidence from molecular data. Plant Systematics and Evolution 302(10): 1445–1456. https://doi.org/10.1007/s00606-016-1343-1

Azadbakht J, Darvishnia M, Hayati J, Azadbakht N. 2013. Four new host records for powdery mildew fungi from Iran. Iranian Journal of Forest and Range Protection Research 10: 114–119.

Bradshaw M, Tobin P. 2020. Sequencing herbarium specimens of a common detrimental plant disease (powdery mildew). Phytopathology 110: 1248–1254. https://doi.org/10.1094/PHYTO-04-20-0139-PER

Bradshaw M, Braun U, Götz M, Jurick W. 2021. Phylogeny and taxonomy of powdery mildew caused by *Erysiphe* species on *Lupinus* hosts. Mycologia: 114:1, 76-88. https://doi.org/10.1080/00275514.2021.1973287

Braun U, Cook R. 2012. Taxonomic manual of the *Erysiphales*. CBS Biodiversity Series 11. 707 p.

Braun U, Kruse J, Wolcan SM, Murace M. 2010. Three new species of the genus *Erysiphe* (*Ascomycota*, *Erysiphales*) on legumes and some new combinations. Mycotaxon 112: 173–187. https://doi.org/10.5248/112.173

Edgar RC. 2004. Muscle: Multiple sequence alignment with high accuracy and high throughput. Nucleic Acids Research 32: 1792–1797. https://doi.org/10.1093/nar/gkh340

Ellingham O, David J, Culham A. 2019. Enhancing identification accuracy for powdery mildews using previously underexploited DNA loci. Mycologia 111: 798–812. https://doi: 10.1080/00275514.2019.1643644

Felsenstein J. 1985. Confidence limits on phylogenies: an approach using the bootstrap. Evolution 39: 783–791. https://doi.org/10.1111/j.1558-5646.1985.tb00420.x

Gholami H, Mirhadi SA, Rezayazdi K. 2017. Estimation of energy content of Iranian sainfon using chemical composition and in vitro gas production. Animal Production 18: 741–748.

Kiss L, Vaghefi N, Bransgrove K, Dearnaley JDW, Takamatsu S, Tan YP, Marston C & al. 2020. Australia: a continent without native powdery mildews? The first comprehensive catalog indicates recent introductions and multiple host range expansion events, and leads to the re-discovery of *Salmonomyces* as a new lineage of the *Erysiphales*. Frontiers in Microbiology 11: 1571. https://doi.org/10.3389/fmicb.2020.01571

Kumar S, Stecher G, Tamura K. 2016. MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets. Molecular Biology and Evolution 33: 1870–1874. https://doi.org/10.1093/molbev/msw054

Meeboon J, Takamatsu S. 2017. Notes on powdery mildews (*Erysiphales*) in Thailand III. *Erysiphe* species on *Fabaceae*, *Fagaceae*, *Hydrangeaceae* and *Lamiaceae*. Tropical Plant Pathology 42: 239–249. https://doi.org/10.1007/s40858-017-0137-5

Mori Y, Sato Y, Takamatsu S. 2000. Evolutionary analysis of the powdery mildew fungi nucleotide sequences of the nuclear ribosomal DNA. Mycologia 92: 74–93. https://doi.org/10.1080/00275514.2000.12061132

Muzaffariyān, V. 1996. A dictionary of Iranian plant names: Latin, English, Persian. Tehran, Farhange Muaser Publishing, Iran.

Qiu PL, Liu SY, Bradshaw M, Rooney-Latham S, Takamatsu S, Bulgakov TS, Braun U. 2020. Multi-locus phylogeny and taxonomy of an unresolved, heterogeneous species complex within the genus *Golovinomyces* (*Ascomycota*, *Erysiphales*), including *G. ambrosiae*, *G. circumfusus* and *G. spadiceus*. BMC Microbiology 20: 1–16. https://doi.org/10.1186/s12866-020-01731-9

Silvestro D, Michalak I. 2012. raxmlGUI: a graphical front-end for RAxML. Organisms Diversity & Evolution 12: 335–337. https://doi.org/10.1007/s13127-011-0056-0

Takamatsu S, Taguchi Y, Shin HD, Paksiri U, Limkaisang S, Binh NT, Sato Y. 2002. Two *Erysiphe* species associated with recent outbreak of soybean powdery mildew: results of molecular phylogenetic analysis based on nuclear rDNA sequences. Mycoscience 43: 333–341. https://doi.org/10.1007/S102670200049

Walsh PS, Metzger DA, Higuchi R. 1991. Chelex 100 as a medium for simple extraction of DNA for PCR–based typing from forensic material. Biotechniques 10: 506–513.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 283–334

https://doi.org/10.5248/137.283

Cetrarioid lichens from India revised, including *Nephromopsis awasthii* sp. nov. and new records

Gaurav K. Mishra[1], Sanjeeva Nayaka[1]*, Dalip K. Upreti[1], Sergii Y. Kondratyuk[2], Arne Thell[3], Ingvar Kärnefelt[3]

[1]*CSIR-National Botanical Research Institute, Rana Pratap Marg Lucknow-226001 Uttar Pradesh, India*

[2]*M. H. Kholodny Institute of Botany, Tereshchenkivska str. 2, 01004 Kyiv, Ukraine*

[3]*Lund University, Biological Museum, Botanical Collections, Box 117, SE-221 00 Lund, Sweden*

* Correspondence to: *nayaka.sanjeeva@gmail.com*

Abstract—Morpho-taxonomic studies of cetrarioid lichens from India recorded 46 species representing *Cetraria, Melanelia, Nephromopsis*, and *Platismatia. Nephromopsis awasthii* is described as new to science; and *Cetraria endochrysea*, *C. sinensis*, *Melanelia agnata*, *Nephromopsis ciliaris*, *N. morrisonicola*, *N. pseudocomplicata*, *N. pseudoweberi*, *N. rugosa*, *N. weii*, and *N. yunnanensis* are reported for the first time from India. A key to all genera and species of cetrarioid lichens in India is provided together with their detailed morpho-taxonomic characters and distribution.

Key words—ascomycetes, diversity, Himalaya, *Parmeliaceae*, taxonomy

Introduction

Parmeliaceae, the largest lichen family in the world, comprises c. 60 genera and more than 2700 species (Thell & al. 2012, Divakar & al. 2017). As per their morphology foliose, fruticose, and transient erect subfruticose forms occur within *Parmeliaceae* while crustose forms exist only in the phylogenetically ancient subfamily *Protoparmelioideae*. Cetrarioid lichens are characterized by an erect foliose or subfruticose thallus loosely attached to the substrate

and the presence of marginal apothecia and pycnidia (Kärnefelt & al. 1998, Randlane & al. 2013).

Acharius (1803) described the first cetrarioid genus *Cetraria*, while Rassadina (1950) studied *Cetraria* and reported 76 species from different parts of the world. *Cetraria* is widely distributed in the world's temperate, alpine, Arctic, and Antarctic regions. Kärnefelt & al. (1992, 1993) revised the cetrarioid lichens, dividing them into *Cetraria* and more than ten new genera. Randlane & al. (2013) cited 149 cetrarioid lichen species representing 25 genera worldwide. Based on molecular phylogeny, Divakar & al. (2017) synonymized *Allocetraria, Cetrariella, Usnocetraria,* and *Vulpicida* with *Cetraria* and placed *Ahtiana, Arctocetraria, Cetreliopsis, Cetrariopsis, Flavocetraria, Flavocetrariella, Kaernefeltia, Masonhalea, Tuckermanella, Tuckermannopsis,* and *Tuckneraria* in synonymy with *Nephromopsis.*

Babington's (1852) descriptions of *Cetraria ambigua*, *Evernia stracheyi* [= *Cetraria laii*], and *C. stracheyi* [= *Nephromopsis stracheyi*] based on the collections of Strachey & Winterbottom from central Himalaya are the first reports of cetrarioid lichens from India. Subsequently, numerous new records from India have been reported by Awasthi (1982, 2000), Divakar & Upreti (2003, 2006), Sinha & Elix (2003), Mishra & Upreti (2015a,b), and Jagadeesh Ram & Sinha (2010).

For more than five decades, a large number of cetrarioid lichens have been described in various regional floristic accounts of India, but a consolidated account is not available. Here we attempt to provide a detailed enumeration of the cetrarioid lichens of India.

Materials & methods

The present study is based on collections of cetrarioid lichens preserved in the herbarium of the CSIR-National Botanical Research Institute, Lucknow, India (LWG), which also includes the personal herbarium of Dr. Dharani Dhar Awasthi (LWG-AWAS) and Lucknow University Herbarium (LWG-LWU). Some specimens were also borrowed from herbarium of Botanical Survey of India, Sikkim Himalayan Circle, Gangtok (BSHC). In total the study included more than 5000 specimens representing different phytogeographic regions of India. The morphological characters of the specimens were examined by using stereo zoom Leica S8APO and light DM2500 microscopes attached with a camera. All anatomical measurements were recorded in plain water, while 10% KOH was used for detailed study of asci and ascospores. For spot tests the usual reagents of K, C, and P were used and for identification of lichen substances by thin layer chromatography (TLC) was performed in solvent system A and B following Orange & al. (2001). The specimens were identified up to species level with the help of literature of Awasthi (1982, 2007),

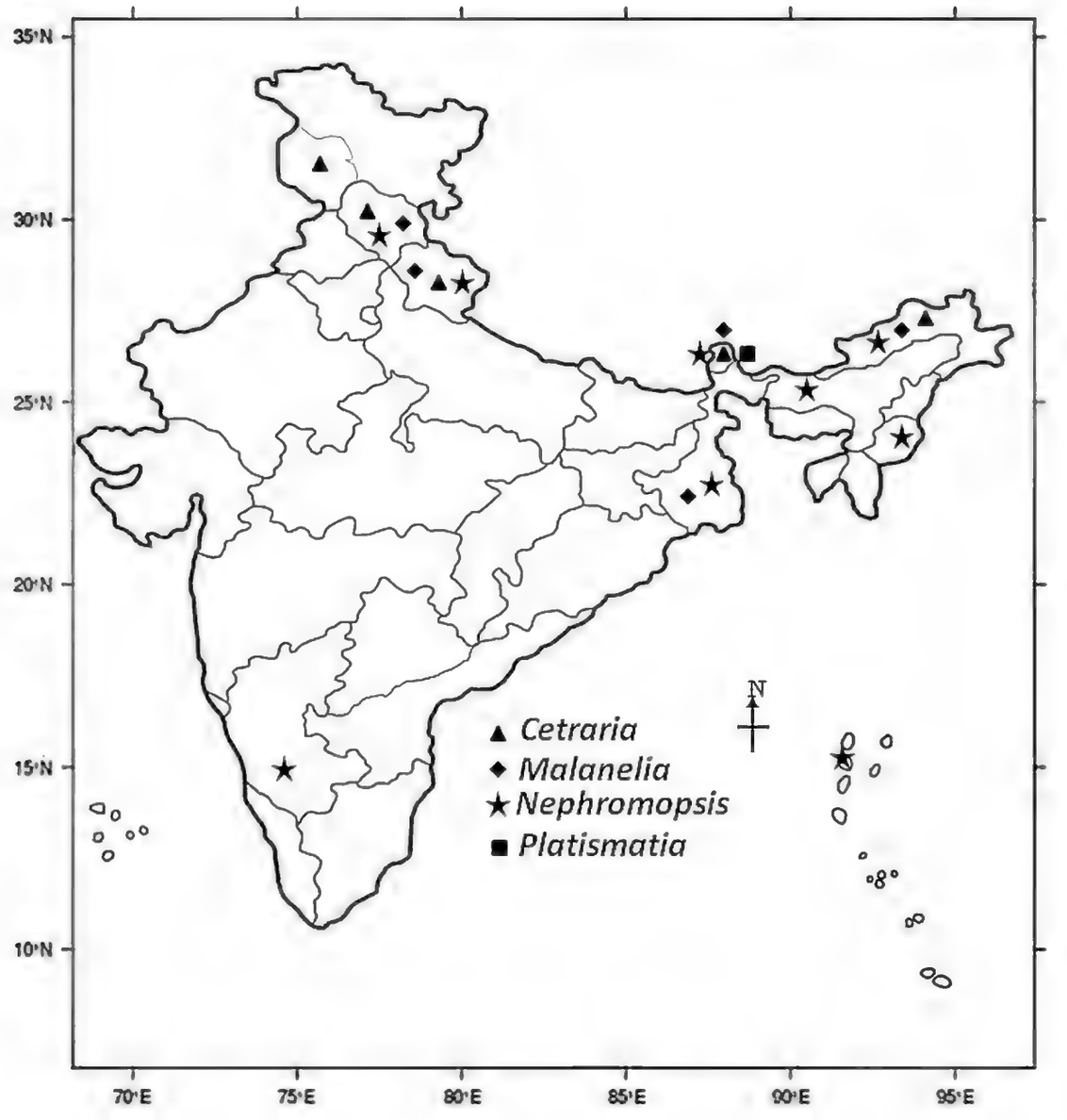


Fig. 1. Map showing the distribution of cetrarioid genera in India.

Thell (1996), Randlane & Saag (1998), Kärnefelt & al. (1993), and Kärnefelt (1979) and confirmed by matching with available type specimens at LWG herbarium.

Results & discussion

The study covers 46 species belonging to four genera of cetrarioid lichens (Fig. 1). *Nephromopsis* was represented by 27 species, *Cetraria* by 16 species, *Melanelia* by three species, and *Platismatia* by one species. Most Indian cetrarioid lichens typically grow on bark (26 species); others grow on soil (14 species) or on rock (4 species). Three species are common on bark and

soil, whereas *Nephromopsis cucullata* and *N. nivalis* occur on both soil and rock. *Cetraria islandica* and *C. muricata* grow in association with mosses; *Melanelia stygia* mostly grows over rocks in association with other lichens such as *Physciaceae* spp.; and *Nephromopsis laii*, *N. pallescens*, and *N. stracheyi* are common on deciduous trees, such as oak and conifers in India.

Within India most cetrarioid lichen species occur in the Himalayan region; 31 species occurring in Sikkim state (Eastern Himalaya), 27 in Uttarakhand (Western Himalaya), 12 in Arunachal Pradesh (Eastern Himalaya), nine each in Himachal Pradesh state and Darjeeling district (West Bengal state), three in Andaman Islands, and two each in Jammu & Kashmir and Manipur. Nine of the 46 species known from India are endemic to the subcontinent: *Cetraria ambigua*, *C. stracheyi*, *Nephromopsis hypotrachyna*, *N. isidioidea*, *N. leucostigma*, *N. melaloma*, *N. nephromoides*, *N. stracheyi,* and *N. sikkimensis*.

Nephromopsis awasthii is proposed here as a new species, based on a morphological analysis. However, there is a need for molecular evidence and additional specimens for comparing infra-species variation and for confirming the generic position. *Cetraria endochrysea*, *C. sinensis*, *Melanelia agnata*, *Nephromopsis ciliaris*, *N. morrisonicola*, *N. pseudocomplicata*, *N. pseudoweberi*, *N. rugosa*, *N. weii,* and *N. yunnanensis* are new distributional records for India.

Most cetrarioid species are corticolous or terricolous, although a few species of *Melanelia* and *Nephromopsis* are saxicolous (Thell 1996). The species growing on soil and rocks form cushions and grow in association with mosses and grasses. Cetrarioid lichens occur primarily in the temperate and alpine regions of India, although some species such as *Cetraria oakesiana, Nephromopsis laii,* and *N. stracheyi* are restricted to lower altitudes between 500–1500 m. The middle altitudinal range (1500–3500 m) in Western and Eastern Himalayan regions are preferred by *Nephromopsis hypotrachyna, N. laii, N. melaloma, N. togashii,* and *N. weii,* which are found growing luxuriantly on various trees such as *Acer oblongum*, *Pinus roxburghii, Quercus oblongata, Juglans regia*, and *Rhododendron* spp. The higher altitude region (>3500 m) in Arunachal Pradesh, Sikkim, and Uttarakhand mostly lacks trees but is characterized by shrubs and grasslands. Here, the cetrarioid lichens mainly grow on rock, soil and branches of shrubs. The common saxicolous cetrarioid lichens (*Melanelia* sp. and *Cetraria* sp.) are also found growing here on exposed boulders. The flat tops of boulders are generally covered with small bushes that provide shade where cetrarioid lichens grow along with grasses and other herbaceous plants. *Cetraria muricata*, *C. nigricans*, *Nephromopsis*

cucullata, and *N. nivalis* occur on soil along the boulders together with grasses and herbs, and small shrubs are often covered with *Nephromopsis hypotrachyna*.

Key to the genera of cetrarioid lichens

1. Pseudocyphellae, if present, occur on both sides 2
1. Pseudocyphellae lacking or sometime present on one side 3
2. Thallus saxicolous, foliose, brown, lobes narrow, sometimes pseudocyphellate; ascospores simple; pycnoconidia bifusiform, cylindrical or fusiform ... ***Melanelia***
2. Thallus terricolous or corticolous, foliose or subfruticose, yellowish grey or straw yellow or brown, lobes wide or narrow, often pseudocyphellate; ascospores globose, subglobose or ellipsoid; pycnoconidia, apical, subapical, swellings, dumb-bell to disc-bar shaped or bacilliform ..... ***Nephromopsis***
3. Thallus foliose, reticulately ridged and veined, pseudocyphellae present on upper surface; thallus containing caperatic acid ..... ***Platismatia***
3. Thallus fruticose, smooth, pseudocyphellae present or absent, if present then marginal or laminal on lower surface and rare on upper surface; thallus containing other lichen substances ..... ***Cetraria***

Cetraria Ach., Meth. Lich.: 292. 1803

Thallus fruticose to subfruticose or caespitose, rarely appressed foliose, several individual thalli usually clumped together into small stands, dorsiventral; lobes subterete, canaliculate to flat, dichotomously or irregularly branched, expanded portions often unbranched; margins usually entire, sometimes undulating or cucullate; marginal projections and cilia present in some; upper surface grey, olive green, brown to reddish brown, emaculate, with or without soredia, lacking isidia; upper cortex bilayered, with a non-pored epicortex; with or without pseudocyphellae, pseudocyphellae marginal or laminal on lower surface, rare on upper surface; without rhizines; medulla white. Apothecia usually submarginal close to lobe apices, sessile to subpedicellate; disc perforate; asci clavate to cylindrical, 8-spored, spores ellipsoidal to subspherical, 6–10 × 3–5 µm. Pycnidia common to rare, at ends of marginal projections; pycnoconidia oblong to citriform, sublageniform or filiform shape.

The genus *Cetraria* is represented by 38 species worldwide (Randlane & al. 2013) of which 16 are known from India, mostly distributed in the alpine region of the Indian Himalayas.

Key to the species of genus *Cetraria* from India

1. Thallus containing usnic acid 2
1. Thallus lacking usnic acid 10

2. Medulla bright yellow or orange 3
2. Medulla white, occasionally pale yellow 4
3. Thallus fruticose, yellowish brown; containing usnic acid in cortex, hybocarpone and secalonic acids ..... *C. endochrysea*
3. Thallus foliose, bright yellow; containing pinastric and vulpinic acids ... *C. pinastri*
4. Thallus terricolous or saxicolous, lobe margins without soredia 5
4. Thallus corticolous, lobe margins with soralia ..... *C. oakesiana*
5. Medulla white 6
5. Medulla yellow to ochraceous. 9
6. Thallus containing fumarprotocetraric acid; medulla P+ orange red ..... *C. flavonigrescens*
6. Thallus containing other lichen substances; medulla P– 7
7. Thallus containing lichesterinic, protolichesterinic, and secalonic acids 8
7. Thallus containing lichesterinic, protolichesterinic, and caperatic acids .. *C. denticulata*
8. Lobes wider, ≤3 mm, upper surface yellowish to grey green; pseudocyphellae lined continuously along the margins on the underside ..... *C. sinensis*
8. Lobes narrower ≤2 mm, upper surface yellow to ochraceous; pseudocyphellae punctiform. ..... *C. ambigua*
9. Lobes distinctly dorsiventral, upper side concave, secondary lobes present ..... *C. globulans*
9. Lobes radially symmetrical, upper side convex, secondary lobes absent ..... *C. laii*
10. Thallus containing fumarprotocetraric acid, medulla K+ yellow then red, P+ reddish 11
10. Thallus containing other lichen substances, medulla K-, P- 12
11. Lobes canaliculate to strongly tubular; pseudocyphellae submarginal, forming a distinct continuous line ..... *C. laevigata*
11. Lobes flat to canaliculate; pseudocyphellae laminal to submarginal, but not in continuous lines ..... *C. islandica*
12. Thallus 1–2 cm tall, shrubby tuft, branched, lobes 0.5–1.5 mm wide 13
12. Thallus more than 2 cm tall, intricately branched, lobes >1.5 mm wide 15
13. Pseudocyphellae present 14
13. Pseudocyphellae absent ..... *C. sepincola*
14. Pseudocyphellae flat and circular; pycnidia on spinules; apothecia not seen ..... *C. muricata*
14. Pseudocyphellae present in form of white dots; pycnidia at lobe margins, apothecia present; ascospores ellipsoidal, 7 × 4.5 µm ..... *C. odontella*
15. Pseudocyphellae distinct, marginal projections absent; medulla hollow ... *C. aculeata*
15. Pseudocyphellae very narrow to indistinct, marginal projections sparse; medulla solid ..... *C. nigricans*

Cetraria aculeata (Schreb.) Fr., Nov. Sched. Critic. Lich.: 32 (1826)

≡ *Lichen aculeatus* Schreb., Spic. Fl. Lips.: 125 (1771)

Thallus fruticose, terricolous, branched, ≤4–6 cm tall, in tuft; lobes 3.5 mm wide; upper surface olive black, smooth, marginal projections absent; lacking isidia and soredia; lower side light black, with deeply concave pseudocyphellae, concave; medulla hollow. Apothecia rare. Pycnidia not seen.

Chemistry—Medulla K–, C–, P–, KC–; protolichesterinic acid present in TLC.

Specimen examined—**INDIA, Uttarakhand, Uttarkashi district**, Gomukh area, alt. 3200–3800 m, on soil, D.D. Awasthi & S.R. Singh s.n. (LWG-AWAS).

Remarks—*Cetraria aculeata,* which is closely related to *C. muricata,* is generally distinguished by its hollow medulla and deeply concave pseudocyphellae.

Ecology & distribution—*Cetraria aculeata* occurs on soil reaching elevations up to ca. 3800 m and has been reported from the western Himalaya region of Uttarakhand.

Cetraria ambigua C. Bab., Hooker's J. Bot. Kew Gard. Misc. 4: 244 (1852)

≡ *Allocetraria ambigua* (C. Bab.) Kurok. & M.J. Lai, Bull. Natl. Sci. Mus. Tokyo, B 17(2): 62 (1991)

Thallus foliose to subfruticose, terricolous, prostrate to erect, ≤1.5–3 cm tall, branched; lobes ≤1–2 mm wide; upper surface yellow to ochraceous, plane to concave, smooth; lacking isidia and soredia; lower side slightly brownish, ± longitudinally reticulately lacunose scrobiculate, with marginal punctiform pseudocyphellae; medulla white. Apothecia rare, marginal to submarginal, ascospores ellipsoid, 7–9 × 4–5 µm. Pycnidia present, marginal; pycnoconidia not found.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex, lichesterinic, protolichesterinic, and secalonic acids present in TLC.

Specimens examined—**INDIA, Himachal Pradesh, Lahul Spiti district**, Baralachala pass, alt. 4700 m, on soil, 4.8.2003, D.K. Upreti & S. Chatterjee 03-001780 (LWG). **Sikkim, North Sikkim**, Donkia, alt. 5200 m, U. Lachungpa 1746 (LWG-LWU), Llonakh valley, Muguthang to Naku La, alt. 4500–4600 m, on soil, Sinha 1583 (BSHC), Yangdi, above Thangu, alt. 4250 m, on bark, 13.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divaker 04-003981/A, 04-003951 (LWG). **Uttarakhand, Uttarkashi district**, Gomukh area right bank, 5th Moraine, alt. 4200 m, on soil, 4.6.1976, D.D. Awasthi & S.R. Singh 8521 (LWG-AWAS), Govind Wildlife Sanctuary, on way to Morinda Tal, alt. 3695 m, on soil, 23.09.2013, G.K. Mishra s.n. (LWG).

Remarks—*Cetraria denticulata,* which is similar to *C. ambigua* in having a white medulla, differs in having punctiform pseudocyphellae and secalonic acid present in the thallus.

Ecology & distribution—*Cetraria ambigua* grows on soil in open shady places between 3695–5200 m and is widely distributed in alpine regions of Himachal Pradesh, Sikkim, and Uttarakhand.

Cetraria denticulata Hue, Nouv. Arch. Mus. Hist. Nat., sér. 4, 1: 85 (1899), nom. illeg., non La Lave (1820)

≡ *Allocetraria denticulata* A. Thell & Randlane, Flechten Follmann: 359 (1995)

Thallus foliose, terricolous or saxicolous, prostrate to erect, ≤2.5–3 cm tall, branched; lobes ≤1.5 mm wide; upper surface greenish yellow, smooth, plane to convex; lacking isidia and soredia; lower side slightly brown or similar to upper surface; medulla white;. Apothecia absent. Pycnidia marginal, emergent, projecting, black; pycnoconidia filiform, 12–15 × 1 μm.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex, lichesterinic, protolichesterinic, and caperatic acids present in TLC.

Remarks—*Cetraria denticulata* is similar to *C. flavonigrescens,* which differs chemically with usnic acid in the cortex and lichesterinic, protolichesterinic, and caperatic acids present in thallus.

Ecology & distribution—*Cetraria denticulata,* which is reported from the alpine region of Sikkim at 4200 m, is rare in India and known only from north Sikkim. The specimen at LWG is not available/found and the description and chemistry are based on Sinha & Singh (2005).

Cetraria endochrysea (Lynge) Divakar, A. Crespo & Lumbsch, Fung. Divers. 84: 111 (2017) Fig. 2A,B

≡ *Dactylina endochrysea* Lynge, Skr. Svalbard Ishavet 59(Suppl. 5): 62 (1933)

Thallus fruticose, terricolous, erect, ≤1–2 cm tall, branched; lobes ≤2 mm wide, sometimes apically almost radially symmetrical; upper surface yellow to pale brownish, convex; margin with black pycnidial papillae; lacking pseudocyphellae, isidia and soredia; lower surface yellow to reddish brown, concave; medulla yellow to orange. Apothecia absent. Pycnidia emergent, pycnoconidia not found.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex; hybocarpone and secalonic acids present in TLC.

Specimens examined—**INDIA**, **Uttarakhand**, **Uttarkashi district**, Govid Wildlife Sanctuary, around Morinda Tal, alt. 3695 m, on soil, D.K. Upreti & R. Bajpai 12-011472, 12-018550 (LWG).

Remarks—In thallus morphology and medulla colouration, *Cetraria endochrysea* is close to *C. stracheyi,* which lacks hybocarpone acid. Similarly, *C. endochrysea* morphologically resembles *C. globulans,* which differs in having

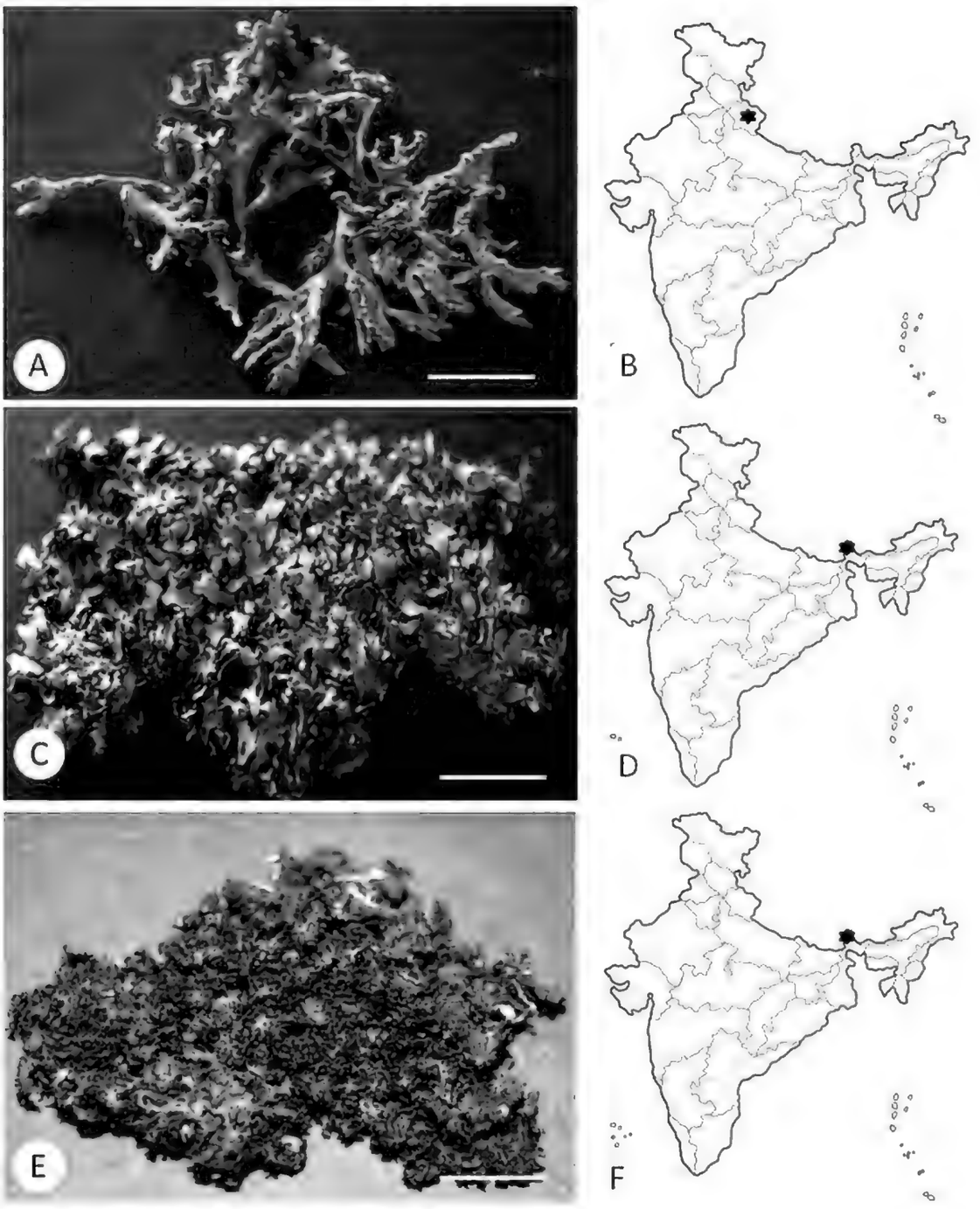


Fig. 2. ***Cetraria endochrysea*** (LWG 12-011472). A. habit; B. Indian distribution. ***Cetraria sinensis*** (LWG 16-037821). C. habit; D. Indian distribution. ***Melanelia agnata*** (LWG 15-026539). E. habit; F. Indian distribution. Scale bars: A, C, E = 1 cm.

a white to pale yellow medulla and the presence of numerous pycnidia along the margin. Previously this species was reported from China (Wei 1991; Kärnefelt & Thell 1996). This is the first record from India.

Ecology & distribution—*Cetraria endochrysea* is common on soil, growing at 3695 m in the alpine region of Uttarakhand.

Cetraria flavonigrescens (A. Thell & Randlane) Divakar, Crespo & Lumbsch, Fungal Diversity 84: 111 (2017)

≡ *Allocetraria flavonigrescens* A. Thell & Randlane, Flechten Follmann: 359 (1995)

Thallus foliose to subfruticose, saxicolous, dorsiventral loosely attached, ≤4 cm across, branched; lobes ≤2 mm wide, linear to laciniate; margin brown; upper surface yellowish with black spots, dull, faintly lacunose, plane to convex, with numerous 1–2 mm tall reticulate maculae; lacking pseudocyphellae, isidia and soredia; lower surface dark brown to black, pale at margins, wrinkled medulla white; rhizines present. Apothecia not seen. Pycnidia emergent, black, marginal to submarginal; pycnoconidia filiform, 12–16 × 1–1.8 µm.

Chemistry—Medulla K–, C–, P+ orange, KC–; usnic acid in cortex, fumarprotocetraric acid present in TLC.

Specimens examined—**INDIA, Sikkim, North Sikkim,** Lonakh valley, Muguthang to Nakula track, alt. 4500 m, on boulders, 1.9.1999, G.P. Sinha 1575 (BSHC). **Uttarakhand, Uttarkashi district**, Bhojwasa, alt. 3700 m, on bark, 5.9.2002, S. Chatterjee & P.K. Divakar 02-000205 (LWG), Gomukh right bank, 4th moraine near Gomukh, alt. 3810 m, 3.07.1976, D.D. Awasthi & S.R. Singh 8438 (LWG-AWAS).

Remarks—*Cetraria flavonigrescens* is similar to *C. ambigua,* which differs primarily in chemistry, with usnic acid in the cortex and lichesterinic, protolichesterinic, and secalonic acids in the medulla.

Ecology & distribution—This species is found only in alpine regions of Sikkim and Uttarakhand between 3700 and 4500 m.

Cetraria globulans (Nyl.) Zahlbr., Trav. de la Sous-Sect. Troïtzkossawsk-Khiakta, Sect. du Pays d'Amour de la Soc. Imp. Russe de Géogr. 12: 89 (1910) ["1909"]

≡ *Platysma globulans* Nyl., Flora 70: 134 (1887)

≡ *Allocetraria globulans* (Nyl.) A. Thell & Randlane, Flechten Follmann: 360 (1995)

Thallus foliose, corticolous or terricolous, branched, ≤3 cm tall; lobes ≤8 mm wide with narrow secondary lobes 1–1.5 mm wide; upper surface yellow to pale brown, plane to concave; pseudocyphellae, isidia, and soredia lacking; lower surface brown with sparse concolorous rhizines; medulla white to pale yellow. Apothecia not seen. Pycnidia numerous, marginal to laminal, located on black, emergent projections; pycnoconidia 10–18 × 0.5–2 µm.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex; lichesterinic, protolichesterinic, and secalonic acids present in TLC.

Specimens examined—**INDIA, Sikkim, North Sikkim,** Lonakh valley, Muguthang to Nakula, alt. 4500 m, on soil, 01.9.1999, G.P. Sinha 1571B (BSHC), Giagaon above,

Thangu, alt. 4600 m, on bark, 13.08.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004005, 04-004012 (LWG).

REMARKS—*Cetraria globulans* is closely related with *C. stracheyi,* which differs in having a yellow and convex upper surface.

ECOLOGY & DISTRIBUTION—*Cetraria globulans* grows on alpine areas of North Sikkim at 4500–4600 m and is known only from North Sikkim in eastern Himalaya.

Cetraria islandica (L.) Ach., Methodus: 293 (1803)

≡ *Lichen islandicus* L., Sp. Pl. 2: 1145 (1753)

THALLUS fruticose, terricolous, divaricately branched, suberect to erect, ≤6.5 cm thick; lobes 2–5 mm wide, involute subcanaliculate; upper surface light to chestnut brown, smooth, margins with dense brown to brown black pycnidial fibrils; pseudocyphellae present, laminal to submarginal, whitish, laminal ones rounded to irregular, submarginal ones linear elongate, scarce; isidia and soredia absent; lower surface yellowish brown to brown, smooth to scrobiculate, shining to dull, pseudocyphellae not seen on lower side; medulla white, solid. APOTHECIA & PYCNIDIA not seen in the examined material (but frequent in the Northern Hemisphere).

CHEMISTRY—Medulla K– or K+ pale to reddish, C–, P+ red, KC–; fumarprotocetraric, protocetraric and protolichesterinic acids present in TLC.

SPECIMENS EXAMINED—**INDIA**, **HIMACHAL PRADESH**, **Kullu district**, Great Himalayan National Park, Around Soupdhar, alt. 3900 m, on soil, 7.9.1999, D.K. Upreti 99-53675/B (LWG). **SIKKIM**, **North Sikkim**, Sebu La base camp, east side, alt. 4960 m, on soil, G.P. Sinha 1236 (BSHC), Theu La-Jakthang way, alt. 4600 m, on soil, G.P. Sinha 1713 (BSHC). **UTTARAKHAND**, **Bageshwar district**, above Phurkia to Mirtoli, alt. 3200 m, on soil, 12.6.1970, D.D. Awasthi 7792 (LWG-AWAS), on way to Pindari Glacier, alt. 3350 m, on soil, 12.6.1970, D.D. Awasthi 7652 (LWG-AWAS), 23.5.1950, D.D. Awasthi 781 (LWG-AWAS), ridge of moraine above Pindari Glacier near zero mile, alt. 4000 m, on soil, 11.6.1970, D.D. Awasthi 7682 (LWG-AWAS); **Chamoli district**, Badrinath between, Vasundhara & Bhagirathi Glacier, alt. 3900-4500 m, on soil, 9.9.1991, D.K. Upreti L13207, L13206/B (LWG), Chopta Tungnath, on soil, October 1994, H.R. Negi L2315 (LWG), Between Wan & Bhuna, alt. 3300 m, on soil, 23.10.1967, A. Singh 91128/A (LWG); **Uttarkashi district**, Gomukh area, right bank, 3rd Moraine, alt. 4200 m, on soil, 3.6.1976, D.D. Awasthi & S.R. Singh 84.25, 24.90 (LWG-AWAS).

REMARKS—*Cetraria islandica* is closely related to *C. laevigata,* which differs in having wider lobes and more distinct laminal pseudocyphellae.

ECOLOGY & DISTRIBUTION—*Cetraria islandica* occurs on soil between altitudes of 3800–4960 m and is the most common and widely distributed *Cetraria* species in India. It has been reported from several localities in

Himachal Pradesh, Sikkim, and Uttarakhand, but is more frequently collected from the western Himalayas.

Cetraria laevigata Rass., Bot. Zh. SSSR 28: 79 (1943)

Thallus fruticose, terricolous, suberect to erect, ≤2.5–6 cm tall, sparsely branched; lobes 3 mm wide, canaliculate to subtubular; upper surface brown to chestnut brown, smooth, margin with brown to black pycnidial fibrils; pseudocyphellae present, distinct, in whitish continuous lines, particularly along tips; isidia and soredia lacking; lower surface light brown, with pseudocyphellae marginal as a continuous line or invisible due to strongly canaliculate tubular nature; medulla white. Apothecia & Pycnidia not seen in the examined material (but frequent in the Northern Hemisphere).

Chemistry—Medulla K+ yellowish or K–, C–, P+ red, KC–; fumarprotocetraric, protocetraric and protolichesterinic acids present in TLC.

Specimens examined—**INDIA, Arunachal Pradesh, West Kameng district**, Bomdila-Sela, Sela Pass, alt. 3600 m, on soil, 18.11.2008, D.K. Upreti, U. Dubey, G.K. Mishra & R. Khare 09-009436 (LWG). **Sikkim, North Sikkim**, Llonakh valley, Chhaber lake below Luna La, alt. 4600 m, on soil, G.P. Sinha 1607 (BSHC), on way between Lashar and GSI old Camp Hut, alt. 4400 m, on soil, Sinha 1202 (BSHC), Yomesamdong, Tembawa river valley, alt. 4750 m, on soil, G.P. Sinha 1261 (BSHC), Yumthang, along river side forest, alt. 3530 m, on soil, G.P. Sinha 1081 (BSHC).

Remarks—*Cetraria laevigata* resembles *C. islandica* but differs in having more tubular lobes.

Ecology & distribution—*Cetraria laevigata* is known to be terricolous, occurring at ca. 3500–4750 m and is reported from eastern Himalaya from different localities of Arunachal Pradesh, and Sikkim.

Cetraria laii Divakar, A. Crespo & Lumbsch,
Fung. Divers. 84: 111 (2017), non *Cetraria stracheyi* C. Bab. (1852)
≡ *Evernia stracheyi* C. Bab., Hooker's J. Bot. Kew Gard. Misc. 4: 244 (1852)
≡ *Allocetraria stracheyi* (C. Bab.) Kurok. & M.J. Lai, Bull.
Nat. Sci. Mus. Tokyo, B 17: 62 (1991)

Thallus fruticose, terricolous, suberect to erect, caespitose, ≤2–2.5 cm tall, branched; lobes ≤2 mm wide, sometimes apically almost radially symmetrical; upper surface yellow grey to brownish, convex; isidia and soredia absent; lower surface also yellow to reddish brown, concave, lacunose to scrobiculate; medulla yellow to ochraceous; margin with black pycnidial papillae. Apothecia rare, marginal to submarginal, ≤2–6 mm in diam., ascospores 5–7 × 4.5 µm. Pycnidia not seen.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex, lichesterinic, protolichesterinic, and secalonic acids present in TLC.

Specimens examined—**INDIA, Jammu & Kashmir, Ladakh district,** Hemis National Park, Rumbak Valley, Tiblis, alt. 4600 m, on bark, 26.7.1999, H.R. Negi L19 (LWG). **Sikkim, North Sikkim**, on way between Lashar and GSI old camp hut, alt. 4400 m, Sinha 1197 (BSHC), Sebu La base camp, west side, alt. 4800 m, Sinha 1210 (BSHC), Llonakh valley, Chhaber lake below Luna La, alt. 4600 m, on soil, G.P. Sinha 1614 (BSHC), on midway between Thangu and Lashar, alt. 4300 m, on soil, G.P. Sinha 1171 (BSHC), Yomesamdong Hot spring surroundings, alt. 4530 m, on soil, G.P. Sinha 1253 (BSHC), Yomesamdong, Tembawa river valley, alt. 4750 m, on soil, G.P. Sinha 1260 (BSHC), Giagaon above, Thangu, alt. 4600 m, on bark, 13.08.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004005 (LWG), Yangdi after Thangu, alt. 4250 m, on rocks, 13.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-003953 (LWG). **Uttarakhand, Bageshwar district**, on way to Phurkia to Mirtoli, alt. 4000 m, on rock, 12.6.1970, D.D. Awasthi 7744 (LWG-AWAS), 23.5.1950, D.D. Awasthi & A.M. Awasthi 781 (LWG-AWAS); **Uttarkashi district**, Gomukh area right bank, 5th Moraine, alt. 4200 m, on soil, 4.7.1976, D.D. Awasthi & S.R. Singh 8527, 8473 (LWG-AWAS), Govind Wildlife Sanctuary, enroute to Morinda Tal, Harki-Dun, alt. 3643, on rock, 12.6.2012, D.K. Upreti & R. Bajpai 12-016184, 12-018553 (LWG).

Remarks—*Cetraria laii* is one of the most common *Cetraria* species in India. In the presence of secalonic acid, *C. laii* is similar to *C. ambigua,* which is distinguished by its distinctly concave lobes (unlike the dorsiventral lobes with the convex upper surface that characterize *C. laii*).

Ecology & distribution—*Cetraria laii* grows abundantly on soil in the alpine region at 4000–4800 m and is distributed in Jammu & Kashmir, Sikkim, and Uttarakhand.

Cetraria muricata (Ach.) Eckfeldt, Bull. Torrey Bot. Club 22: 240 (1895)

≡ *Lichen muricatus* Ach., Lichenogr. Suec. Prodr.: 214 (1798)

≡ *Cornicularia muricata* (Ach.) Ach., Methodus: 302 (1803)

Thallus fruticose, terricolous, shrubby tufts, terete, ≤2 cm tall, densely branched and spinulose; main branches rounded to somewhat flattened; lobes 0.5–1 mm wide, usually with numerous small lateral spinules; upper surface matte to glossy brown, with oval-elliptic, plane, white pseudocyphellae; marginal cilia sparse; isidia and soredia absent; lower surface tan to brown; medulla white, solid. Apothecia not seen. Pycnidia on spinules; pycnoconidia oblong to citriform, 5–6 × 1–1.5 μm.

Chemistry—Medulla K–, C–, P–, KC–; protolichesterinic and rangiformic acids present in TLC.

Specimens examined— **INDIA, Sikkim, North Sikkim**, Theu La bae camp, south side, alt. 4500 m, on soil, G.P. Sinha 1697 (BSHC). **Uttarakhand, Uttarkashi district,**

Govind Wildlife Sanctuary, Har-ki-Dun, Morinda Tal alt. 3695 m, on rock, D.K. Upreti & R. Bajpai 12-011475 (LWG), Gomukh area, right bank, 5th moraine, alt. 4200 m, on soil, 4.7.1976, D.D. Awasthi & S.R. Singh 8488 (LWG-AWAS).

Remarks—*Cetraria muricata* morphologically resembles *C. aculeata,* which differs in having a differently shaped thallus and larger lobes.

Ecology & distribution—This species grows in the Eastern and Western Himalayas in Sikkim and Uttarakhand states at 4000–4500 m.

Cetraria nigricans Nyl., Herb. Musci Fenn.: 109 (1859)

Thallus fruticose, terricolous, ≤3 cm tall, subdichotomously branched; lobes ≤1–2 mm wide, rarely canaliculate; upper surface dark brown to black, marginal projections sparse, 0.25–0.5 mm long pycnidial fibrils and 0.5–1 mm long cilia; pseudocyphellae almost barely visible; rarely sorediate; isidia absent; lower surface pale brown to brown; marginal pseudocyphellae very narrow to indistinct; medulla white. Apothecia ≤10 mm in diam., ascospores 5 × 2.5 µm. Pycnidia not seen.

Chemistry—Medulla K–, C–, P–, KC–; lichesterinic and protolichesterinic acids present in TLC.

Specimens examined—**INDIA, Sikkim, North Sikkim district,** Yangdi, above Thangu, alt. 4250 m, on bark, 13.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-003974, 04-003976, 04-003891, 04-003919, 04-003970 (LWG), Thangu area, alt. 4000 m, on bark, 12.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-003891(LWG), Yangdi above, Thangu, alt. 4250 m, on soil, 13.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-003976, 04-003970, 04-003974 (LWG), Chubuk above, Thangu, alt. 4100 m, on soil, 13.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-003919 (LWG). **Uttarakhand, Bageshwar district**, above Phurkia to Mirtoli, alt. 3200 m, on soil, 12.6.1970, D.D. Awasthi 7799 (LWG-AWAS); **Chamoli district**, near Badrinath way from Mana to Vasudhara, alt. 3350 m, on soil, 21.8.2007, D.K. Upreti & S. Nayaka 07-010128 (LWG), 10 km before Neeti, alt. 3118 m, on soil, 20.8.2007, D.K. Upreti & S. Nayaka 07-01013 (LWG), Badrinath between Vasundhara, alt. 3350 m, on soil, 21.7.2007, D.K. Upreti & S. Nayaka 07-010128 (LWG), 10 km, before Neeti, alt. 3118 m, on soil, 20.8.2007, D.K. Upreti & S. Nayaka 07-010103 (LWG); **Pithoragarh district**, above Phurkia to Mirtoli, alt. 3800 m, on soil, 12.6.1970, D.D. Awasthi 7799 (LWG-AWAS); **Uttarkashi district**, Govind Wildlife Sanctuary, near Har-ki-Dun, alt. 3513 m, on rock, 12.6.2012, D.K. Upreti & R. Bajpai 12-018544 (LWG).

Remarks—*Cetraria nepalensis,* which also has a pseudocyphellate thallus and marginal cilia differs from *C. nigricans* in having short cilia and wider lobes.

Ecology & distribution—*Cetraria nigricans* is widely distributed in alpine areas of Himalayas at 3118–4200 m. Previously known only from Sikkim (Singh & Sinha 2010), the present study extends its distribution to Uttarakhand.

Cetraria oakesiana Tuck., Boston J. Nat. Hist. 3: 445 (1841)

≡ *Usneocetraria oakesiana* (Tuck.) M.J. Lai & J.C. Wei, J. Natl. Taiwan Mus. 60(1): 58 (2007)

Thallus foliose to subfoliose, corticolous, ≤4 cm across; lobes 1-4 mm wide; upper surface yellowish green; soredia present, marginal, farinose; without pseudocyphellae; soredia present and isidia absent; lower surface white to brownish, lacking pseudocyphellae, with a few scattered rhizines; rhizines, simple, black, 0.5–0.8 mm long; medulla white. Apothecia not seen. Pycnidia marginal, often at the edge of soralia apical on ≤0.5 mm long; pycnoconidia filiform, slightly thicker at one end, c. 9–10 × 1 µm.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex; lichesterinic, protolichesterinic, and secalonic acids present in TLC.

Specimen examined—**INDIA, Uttarakhand, Pithoragarh district**, Binsar forest, alt. 1450 m, on bark, May 2006, S. Bhatt 06-010845/B (LWG).

Remarks—In having marginal soralia, *C. oakesiana* is morphologically similar to *Nephromopsis laureri,* which differs in its thinner, more ascending lobes with scattered pseudocyphellae on the lower side and ≤5 µm long bifusiform pycnoconidia.

Ecology & distribution—*Cetraria oakesiana* has restricted distribution in Uttarakhand, occurring on bark at 1450 m.

Cetraria odontella (Ach.) Ach., Syn. Meth. Lich.: 230 (1814)

≡ *Lichen odontellus* Ach., Lichenogr. Suec. Prodr.: 213 (1798)

≡ *Cornicularia odontella* (Ach.) Röhl., Deutschl. Fl. 3 Abt. 2: 141 (1813)

Thallus fruticose, terricolous, loosely attached, erect, densely branched ≤0.5–2 mm tall; lobes ≤0.3–1.5 mm wide; both cilia and marginal projections which bear pycnidia are present along the margins of the lobes; cilia 0.3–0.8 mm; upper and lower surfaces pale brown to brown (dark brown in the older basal parts, pale brown to reddish brown above); pseudocyphellae present in the form of small white dots; isidia and soredia lacking; medulla white. Apothecia ≤10–15 mm wide, asci 30 × 8 µm, ascospores ellipsoidal 7 × 4.5 µm. Pycnidia marginal; pycnoconidia oblong-citriform to slightly bifusiform ca. 3.6–4.8 × 0.5 µm.

Chemistry—Medulla K–, C–, P–, KC–; No lichen substance present in TLC.

Specimen examined—**INDIA, Uttarakhand, Uttarkashi district**, Gomukh area right bank, 5th and 6th moraines, alt. 3780 m, on soil, 4.7.1976, D.D. Awasthi & S.R. Singh s.n. (LWG-AWAS).

Remarks—*Cetraria odontella* is similar to *C. nigricans* in bearing pseudocyphellae and marginal cilia, but *C. nigricans* has wider lobes and a taller (≤3 mm) thallus.

Ecology & distribution—*Cetraria odontella* was found on soil at 3780 m, so far collected only at this single locality in Uttarakhand.

Cetraria pinastri (Scop.) Gray, Nat. Arr. Brit. Pl. 1: 432 (1821)

≡ *Lichen pinastri* Scop. Fl. carniol., Edn 2 (Wien) 2: 382 (1772)

≡ *Vulpicida pinastri* (Scop.) J.-E. Mattsson & M.J. Lai, Mycotaxon 46: 428 (1993)

Thallus foliose, corticolous, loosely appressed to the substratum, 1–3 cm across; lobes narrow, imbricate, 2–4 mm wide, flat or slightly canaliculate with short branches; margin undulate; upper surface bright yellow to yellowish green, smooth, with marginal soralia, occasionally spreading to submarginal parts; soredia farinose, yellow; isidia and soredia lacking; lower surface grayish to brownish, lamellose rugose with dark brown; rhizines present, 1–2 mm long; medulla yellow. Apothecia marginal to submarginal, 1–4 mm diam., margin weakly crenulate sorediate, disc concave, dark brown, shiny; asci broadly clavate 25–35 × 10–12 µm, ascospores spherical 10–12 × 5–8 µm. Pycnidia rare, on projection; pycnoconidia pyriform to almost spherical 80–120 × 70–100 µm.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in the cortex; pinastric and vulpinic acids in TLC.

Specimens examined—**INDIA, Jammu & Kashmir, Baramulla district**, Gulmarg, North side of Gulmarg, alt. 2520 m, on bark, 24.7.2005, M. Sheikh 05-006030 (LWG). **Himachal Pradesh, Kinnaur district**, Chhitkul forest area, alt. 3900–4000 m, on bark, 4.11.2003, D.K. Upreti, R. Srivastava & P. Singh 03-002718, 03-002737, 03-002746 (LWG), 11.5.2014, G.K. Mishra s.n. (LWG). **Uttarakhand, Chamoli district**, Malari, alt. 3000 m, on bark, 28.6.2007, S. Rawat 07-008622 (LWG), way to Niti, 10 km before Gamsali, alt. 3300 m, on bark, 20.8. 2007, D.K. Upreti & S. Nayaka 07-011206 (LWG); **Uttarkashi district**, on way to Gomukh, 11 before Gangotri, alt. 11600ft., on bark, 30.6.1976, D.D. Awasthi & S.R. Singh 8360, 8327, 8285, 8597 (LWG-AWAS), Gomukh area right bank, 6th moraine, alt. 4100 m., on bark, 5.7.1976, D.D. Awasthi & S.R. Singh 8554 (LWG-AWAS).

Remarks—*Cetraria pinastri* is easily recognized by its characteristic yellow colour and sorediate lobe margins. *Cetraria pinastri,* which is closely related to *C. juniperina* (L.) Ach. in having similar chemistry, presence of pinastric and vulpinic acids, but *C. juniperina* lacks soredia.

Ecology & distribution—*Cetraria pinastri* commonly grows on bark at 2500–4000 m in Jammu & Kashmir, Himachal Pradesh, and Uttarakhand.

Cetraria sepincola (Hoffm.) Ach., Meth. Lich.: 297 (1803)

≡ *Lichen sepincola* Ehrh., Pl. crypt. exsicc.: no. 90 (1785)

≡ *Tuckermannopsis sepincola* (Hoffm.) Hale, Bryologist 90: 164 (1987)

Thallus foliose to subfruticose, corticolous, orbicular, 1–1.7 cm across; lobes radiating, irregularly incised or rounded, 1–2.5 mm wide; upper surface olive brown or ashy brown, smooth, dull; isidia and soredia lacking; lower surface pale brown, weakly wrinkled; rhizines pale, simple, scattered; medulla white. Apothecia abundant, submarginal, 1–3 mm across; disc red brown, shining, epruinose, ascospores simple, ellipsoid, 5.3–6.4 × 4–5 μm. Pycnidia numerous; pycnoconidia not seen.

Chemistry—Medulla K–, C–, P–, KC–; protolichesterinic acid present in TLC.

Specimen examined—**INDIA, Sikkim, North Sikkim**, Theu La base camp, south side, alt. 4500 m, on *Rhododendron* bark, G.P. Sinha 1682 (BSHC).

Remarks—*Cetraria sepincola* forms shrubby tufts, lacking pseudocyphellae and rhizines and resembles *Nephromopsis chlorophylla* in having protolichesterinic acid, but *N. chlorophylla* differs in having soredia and a yellowish brown upper surface.

Ecology & distribution—*Cetraria sepincola,* which grows on *Rhododendron* bark at 4500 m, is rare in India and reported only from north Sikkim. Since the specimen has not been located, the description is based on Sinha & Singh (2005).

Cetraria sinensis (X.Q. Gao) Divakar, A. Crespo & Lumbsch, Fungal Diversity 84: 111 (2017) Fig. 2c,d

≡ *Allocetraria sinensis* X.Q. Gao, Flechten Follmann: 365 (1995)

≡ *Usnocetraria sinensis* (X.Q. Gao) M.J. Lai & J.C. Wei, J. Natnl Taiwan Mus.60(1): 57 (2007)

Thallus fruticose, terricolous, suberect to erect, ≤2.5–5 cm tall, sparsely branched; lobes ≤3 mm wide, narrow channeled long lobes; upper surface yellowish to grey greenish, smooth, margin with brown to black pycnidial fibrils; pseudocyphellae present, distinct, as a continuous whitish line along the lower surface, particularly close to tips; isidia and soredia lacking; lower surface light brown, with pseudocyphellae, marginal in a continuous line; medulla white. Apothecia not seen. Pycnidia marginal, located on black and somewhat emergent projections; pycnoconidia 5 – 12 × 0.5 – 1.5 μm.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex; lichesterinic, protolichesterinic, and secalonic acids present in TLC.

Specimen examined—**INDIA, Sikkim, North Sikkim,** Kabi-Tingda, on soil, alt. 3685 m, 18.10.2016, R. Bajpai 16-037821 (LWG).

Remarks—*Cetraria sinensis* shares similar secondary metabolites and a yellowish upper surface with *C. globulans,* which differs in lacking pseudocyphellae; *C. sinensis* is similar to *C. ambigua* in chemistry and colour of thallus, but *C. ambigua* differs in a yellowish lower surface.

Ecology & distribution—*Cetraria sinensis* occurs on soil and was recorded from a single site at 3695 m in the subalpine region of Sikkim. Previously known from China and Nepal (Wang & al. 2015), this is the first record of *C. sinensis* from India.

Melanelia Essl., Mycotaxon 7: 46 (1978)

Thallus foliose, dorsiventral, heteromerous, corticated on both surfaces; lobes narrow, often somewhat elongate, flat to rather distinctly convex or concave; upper surface with or without pseudocyphellae, brown, HNO_3–; or HNO_3 +; upper cortex paraplectenchymatous with non-pored epicortex; lower surface black; rhizines simple. Apothecia laminal, immersed lecanorine; asci 8-spored; ascospores colourless, simple. Pycnidia laminal or marginal; pycnoconidia bifusiform, cylindrical, or fusiform 6–10 × 1 µm.

Three of the four species of *Melanelia* known from the world are present in India.

Key to the species of genus *Melanelia* from India

1. Thallus upper surface glossy brownish black to greenish brown; secondary metabolites absent (all spot reactions are negative) ..... ***M. agnata***
1. Thallus upper surface greenish brown to dark brown or black; secondary metabolites present (at least some spot reactions are positive) 2
2. Thallus forming a mat-like rosette, appressed; lobes 0.5–1.5 mm wide with marginal pycnidial papillae; thalline exciple lacking retrorse hairs .. ***M. hepatizon***
2. Thallus not forming a mat, loosely appressed; lobes 0.5–3 mm wide; thalline exciple with retrorse hairs at the base ..... ***M. stygia***

Melanelia agnata (Nyl.) A. Thell, Nova Hedwigia 60(3–4): 416 (1995) Fig. 2E,F

≡ *Platysma agnatum* Nyl., Flora, Jena 60: 502 (1877)

≡ *Cetraria agnata* (Nyl.) H. Kristinsson, Lichenologist 6: 144 (1974)

Thallus foliose, corticolous or saxicolous, appressed, 1–9 cm diam.; lobes 0.5–2.5 mm wide, usually concave; upper surface glossy brownish black to greenish brown; soredia and isidia absent; lower surface pale brown, sometimes wrinkled, margin dark coloured; rhizines laminal to marginal,

simple to irregularly branched, black; pseudocyphellae conspicuous, whitish, laminal or submarginal; medulla white. Apothecia not seen. Pycnidia common, marginal to laminal emergent or somewhat immersed; pycnoconidia bifusiform, dumb-bell shaped, 4.5–7 × 1–1.5 µm.

Chemistry—Medulla K–, C–, P–, KC–; no lichen substance present in TLC.

Specimen examined—**INDIA, Arunachal Pradesh, Tawang district**, Sela Pass, alt. 4135 m, on boulders, 17.06.2015, R. Bajpai 15-026539 (LWG).

Remarks—*Melanelia agnata* closely resembles *M. hepatizon* and *M. stygia* morphologically. *Melanelia hepatizon* can be distinguished by the presence of inconspicuous pseudocyphellae, smooth lobes, and the presence of stictic and norstictic acids, while *M. stygia* differs in the presence of caperatic and fumarprotocetraric acids in the thallus.

Ecology & distribution—A single specimen was collected at 4135 m in Arunachal Pradesh. Previously known from Iceland and Russia (Thell 1995), this is the first report of *Melanelia agnata* from India.

Melanelia hepatizon (Ach.) A. Thell, Nova Hedwigia 60: 419 (1995)

≡ *Lichen hepatizon* Ach., Lichenogr. Suec. Prodr.: 110 (1798)

≡ *Cetraria hepatizon* (Ach.) Vain., Term. Füz. 22: 278 (1899)

≡ *Tuckermannopsis hepatizon* (Ach.) Kurok., J. Jap. Bot. 66: 158 (1991)

Thallus foliose, saxicolous, appressed, 1–8 cm across; lobes 0.25–1.5 mm broad, irregularly divided and branched, often concave; upper surface shiny greenish brown to dark brown or black, glossy to mat, margin and lamina with short, black pycnidial papillae; lacking isidia and soredia; lower surface dark brown-black, mat; rhizines scattered, laminal to marginal, simple to irregularly branched, black; pseudocyphellae 0.1–0.5 mm long, rounded to elongate and irregular, whitish to obscure, marginal and rarely laminal; medulla white. Apothecia marginal, ≤1–2 mm in diam.; ascospores 8–12 × 5–7.5 µm. Pycnidia frequent, marginal to laminal, immersed, sessile or slightly pronounced; pycnoconidia bifusiform, dumb-bell shaped, 4–7 × 1–1.5 µm.

Chemistry—Medulla K–, C–, P+ orange, KC–; stictic and norstictic acids present in TLC.

Specimens examined—**INDIA, Sikkim, North Sikkim district,** Yangdi, above Thangu, alt. 4250 m, on soil, 13.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-003978, 04-003884, 04-003966, 04-004010, 04-003850, 04-003918 (LWG); **North Sikkim**, Llonakha valley, near Chhaber lake, below Luna La, alt. 4600 m, on rock, G.P. Sinha 1589B, 1596 (BSHC). **Uttarakhand, Uttarkashi district**, on way to Gomukh, near Bhojwasa, alt. 4000 m, on soil, 30.6.1976, D.D. Awasthi & S.R. Singh

8379 (LWG-AWAS), Near Gangotri towards Gomukh, alt. 3150 m, on soil, 30.6.1976, D.D. Awasthi & S.R. Singh 8489/B (LWG-AWAS), after Chirwasa, alt. 3600 m, on rock, 5.9.2002, S. Chatterjee & P.K. Divakar 02-000193 (LWG).

Remarks—*Melanelia hepatizon* is distinguished by the brown-black upper side of the thallus, P+ orange medullary reaction and the crenulate margin of the apothecia. *M. hepatizon* morphologically resembles *M. stygia,* but *M. stygia* differs in having a P+ orange reaction and laminal pseudocyphellae.

Ecology & distribution—*Melanelia hepatizon* grows on exposed rocks and boulders at 4100–4600 m in dry temperate to alpine regions of Sikkim and Uttarakhand.

Melanelia stygia (L.) Essl., Mycotaxon 7(1): 47 (1978)

≡ *Lichen stygius* L., Sp. Pl. 2: 1143 (1753)

≡ *Parmelia stygia* (L.) Ach., Methodus: 203 (1803)

Thallus foliose, saxicolous, adnate to loosely attached, 8 cm across; lobes ≤3 mm wide; margin weakly crenulate; upper surface olive-brown to darker, concave to convex, dull to shining at apices; pseudocyphellae submarginal to laminal, rounded to elongate and irregular, 0.1–0.5 mm long, irregular to effigurate, whitish; isidia and soredia lacking; lower surface black; rhizines scattered, laminal to marginal, simple, black, 2–3 mm long; medulla white. Apothecia ≤10 mm in diam., ascospores 10–17 × 4.5–8 µm. Pycnidia frequent, marginal to laminal, immersed to sessile; pycnoconidia bifusiform, 4–7 × 1–1.5 µm.

Chemistry—Medulla K–, C–, P– or P+ orange, KC–; caperatic and fumarprotocetraric (±) acids present in TLC.

Specimens examined—**INDIA, Arunachal Pradesh, West Kameng district**, 7 km before Sela pass, alt. 3835 m, on bark, 12.11.2008, D.K. Upreti, U. Dubey, G.K. Mishra & R. Khare 08-009374/D (LWG); **Tawang district**, Naguia, alt. 4290 m, on rock, 25.9.2012, R. Debnath 12-017795 (LWG). **Himachal Pradesh, Kullu district**, Marchi, on way to Rohtang Pass, alt. 3301 m, on soil, 31.5.2013, R. Bajpai 13-023268 (LWG), Great Himalayan National Park, Pardi, alt. 3240 m, on rock, Nov. 2002, S. Nayaka & R. Srivastava 02-001010, 02-001256 (LWG), 7.9.1990, D.K. Upreti 99-53661 (LWG); **Kinnaur district**, in and around Puh, alt. 3000 m, on soil, 1.11.2003, D.K. Upreti & R. Srivastava 03-002612 (LWG); Recong Peo, on way from Chini to Pangi village, alt. 2900 m, on rock, 3.11.2003, D.K. Upreti, R. Srivastava & Prakash 03-002682, 03-0026660 (LWG); **Lahul Spiti district**, Darcha, alt. 3200 m, on rock, 4.8.2003, D.K. Upreti & S. Chatterjee 03-001718, 03-001733, 03-001753 (LWG); Chota Dara, alt. 3600 m, on rock, 3.8.2002, D.K. Upreti & P.K. Divakar 02-000077/A (LWG); **Shimla district**, Rohu Chanshal pass, alt. 3632 m, on bark, 24.8.2016, R. Bajpai 16-030241, 16-030248, 16-30343 (LWG). **Sikkim, South Sikkim district,** Kupup, around Bethang lake, alt. 4100

m, on rock, G.P. Sinha 1437 (BSHC), on way between Phuni-Yakche, alt. 3000 m, on rock, G.P. Sinha 1088 (BSHC), Thangu, along Teesta bank, alt. 3800 m, on rock, G.P. Sinha 1145 (BSHC), Sebu La Base Camp, west side, alt. 4500–4800 m, on rock, G.P. Sinha 1224 B (BSHC); **West Sikkim**, Dzongri, alt. 4000 m, on rock, G.P. Sinha 787, 788, 789 (BSHC), Thangsing-Samiti foot track, alt. 3700 m, on rock, G.P. Sinha 834 (BSHC). **Uttarakhand, Bageshawar district**, Dwali to Phurkia, alt. 3500 m, on rock, 10.6.1970, D.D. Awasthi 7653, 7643 (LWG-AWAS); **Chamoli district**, Between Wan to Bhuna, alt. 3300 m, on rock, 23.10.1967, A. Singh 91586 (LWG); **Rudraprayag district**, Rudraprayag temple, alt. 2200 m, on rock, 28.8.2006, D.K. Upreti, S. Chatterjee & B. Kumar 06-006209 (LWG), Kedarnath valley, around temple, alt. 3500 m, on rock, 28.8.2006, D.K. Upreti, P.K. Divakar & B. Kumar 06-006222 (LWG). **West Bengal**, **Darjeeling district**, way from Sandakphoo to phalut, alt. 3600 m, on bark, 16.6.1967, D.D. Awasthi & M.R. Agrawal 67.462, 67.468 (LWG-LWU).

Remarks—*Melanelia stygia* is morphologically similar to *Montanelia panniformis* (Nyl.) Divakar & al. (≡ *Melanelia panniformis* (Nyl.) Essl.), which lacks fumarprotocetraric acid in the thallus.

Ecology & distribution—*Melanelia stygia* grows on exposed rocks at 3700–4600 m and is widely distributed in the alpine regions of Arunachal Pradesh, Himachal Pradesh, Sikkim, Uttarakhand, and West Bengal.

Nephromopsis Müll. Arg., Flora 74: 374 (1891)

Thallus foliose to subfruticose, often large, irregularly lobate; lobes dichotomously to irregularly branched; margin undulating; upper surface yellowish green, grey or straw yellow or brown, smooth, rugose to reticulate; with or without isidia, soredia and pseudocyphellae; upper cortex paraplectenchymatous, with non-pored epicortex; lower surface usually dark brown to black with punctiform pseudocyphellae; rhizines simple, sparse; medulla white or pigmented. Apothecia usually submarginal, nephromoid or non-nephromoid (developing on the underside of the margin); asci 8 spored, clavate; ascospores hyaline simple, subglobose, globose or ellipsoid, subspherical, 5–7 µm in diam. Pycnidia marginal and laminal, emergent; pycnoconidia usually with two swellings, dumb-bell to disc-bar shaped (rarely without swelling, bacilliform), 5–6 × 1 µm.

Out of 58 species of *Nephromopsis* known worldwide (Randlane & al. 2013), 26 species are represented in India.

Key to the species of genus *Nephromopsis* from India

1. Thallus containing usnic acid 2
1. Thallus lacking usnic acid 23

2. Pseudocyphellae present on upper or lower surface,
± black rimmed and with black fibrils at the rim;
fumarprotocetraric acid absent (other lichen substances present) 3

2. Pseudocyphellae present on both surfaces,
black rimmed, with or without black fibrils at the rim;
fumarprotocetraric acid present 21

3. Thallus mainly terricolous; lobes elongate, usually narrow, 2–10 mm wide 4

3. Thallus corticolous and terricolous; lobes short, 8–30 mm wide 5

4. Thallus pale yellowish to yellow; lobes canaliculate to tubular,
surface smooth; lower part reddish ..... ***N. cucullata***

4. Thallus yellow to dark yellow; lobes planar,
surface foveolate and wrinkled; lower part dark yellow ..... ***N. nivalis***

5. Thallus terricolous, subfruticose, suberect; laciniate lobate 6

5. Thallus corticolous or otherwise, foliose, horizontally spreading 7

6. Lower surface brown,
pseudocyphellae white and very distinct ..... ***N. leucostigma***

6. Lower surface yellow to brown,
pseudocyphellae grey as a distinct dark line ..... ***N. melaloma***

7. Thallus sorediate or isidiate 8

7. Thallus without soredia or isidia 9

8. Thallus sorediate, soredia white, marginal ..... ***N. laureri***

8. Thallus isidiate, isidia marginal or laminal ..... ***N. togashii***

9. Medulla yellow 10

9. Medulla white 11

10. Pseudocyphellae laminal or on ridges and plug-like outgrowths;
lower surface strongly reticulate or rugose ..... ***N. isidioidea***

10. Pseudocyphellae laminal or on ridges along the thallus margin;
lower surface moderately reticulate ..... ***N. ornata***

11. Marginal cilia present 12

11. Marginal cilia absent 19

12. Upper surface greenish brown;
thallus containing alectoronic acid ..... ***N. pseudocomplicata***

12. Upper surface grey, yellowish to brown;
thallus containing other lichen substances 13

13. Thallus coriaceous, dorsiventral;
lobules marginal to submarginal, pycnoconidia citriform ..... ***N. sikkimensis***

13. Thallus membranaceous, lobules absent, pycnoconidia bifusiform ..... ***N. ahtii***

14. Apothecia small, ≤5 mm in diam., non-nephromoid, exciple 2-layered 15

14. Apothecia large, nephromoid, exciple 2- or 3-layered 25

15. Pseudocyphellae on ridges and outgrowths of the very rugose lower surface ..... ***N. yunnanensis***
15. Pseudocyphellae present on directly on the surface, lacking on ridges and outgrowths 16

16. Medulla KC+ red or C+ pink 17
16. Medulla KC- and C- 18

17. Apothecia numerous, mainly laminal to submarginal; thallus containing lichesterinic, protolichesterinic, alectoronic, and a-collatolic acids ..... ***N. pallescens***
17. Apothecia sparse, marginal; thallus containing usnic and olivetoric acids ..... ***N. rugosa***

18. Upper surface yellow, lower surface black; pseudocyphellae present, lacking plug like outgrowths; pycnidia black, emergent, marginal and laminal ..... ***N. morrisonicola***
18. Upper surface greenish yellow, lower surface brownish; pseudocyphellate on lamellae and on plug-like outgrowths ..... ***N. laii***

19. Medulla C+ red, KC+ red; anziaic acid present ..... ***N. stracheyi***
19. Medulla C-, KC-; no lichen substance present 20

20. Thallus small, numerous pycnidia on upper and lower surfaces, lower surface reticulately ridged, veined, and pseudocyphellate; ascospores globose and subglobose ..... ***N. awasthii***
20. Thallus large, lacking fibrils along margins, lower surface smooth or wrinkled with pseudocyphellae directly on the surface; ascospores oblong to ellipsoid ..... ***N. nephromoides***

21. Medulla yellow ochraceous ..... ***N. endoxanthoides***
21. Medulla white 22

22. Medulla P+ red; fumarprotocetraric, protocetraric, and traces of lichesterinic and protolichesterinic acids present ..... ***N. rhytidocarpa***
22. Medulla P+ orange; salazinic and norstictic acids present ..... ***N. hypotrachyna***

23. Pseudocyphellae present on both surfaces, upper surface shiny brown ..... ***N. weii***
23. Pseudocyphellae present or absent 24

24. Thallus sorediate and containing protolichesterinic acid ..... ***N. chlorophylla***
24. Thallus lacking soredia and chemistry otherwise 25

25. Upper surface grey to yellowish, lobe margins ciliate; thallus containing atranorin and olivetoric acids ..... ***N. ciliaris***
25. Upper surface dark brown to reddish brown, lobe margins eciliate; thallus containing caperatic acid ..... ***N. pseudoweberi***

Nephromopsis ahtii (Randlane & Saag) Randlane & Saag,
Mycol. Progr. 4(4): 311 (2005)

≡ *Tuckneraria ahtii* Randlane & Saag in Randlane & al., Acta Bot. Fenn. 150: 147 (1994)

Thallus foliose, corticolous, loosely adnate, horizontally spreading, ≤10 cm across; lobes 4–10 (–25) mm wide, rounded to elongate, convolute, margin smooth to crenate, ciliate, pycnidiate; cilia pale to brown, ≤5 mm long; pycnidia dense or sparse, black in fibrils; upper surface grey or brown to yellowish green, smooth to faintly rugose in central part; soredia and isidia absent; lower surface black, bearing conspicuous, black marginal pycnidial projections; rhizines present in central part of thallus, brown, simple, 1.5–3 mm long; pseudocyphellae present, white, pale brown to dark brown. Apothecia small, marginal, nephromoid, with oblong or reniform brown disc, 2–5 mm diam.; asci narrowly clavate 10–30 × 6–9 µm; ascospores subglobose 5–9 × 4–5 µm. Pycnidia marginal, emergent projections; pycnoconidia bifusiform 5 × 1.5 µm.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex; lichesterinic and protolichesterinic acids present in medulla in TLC.

Specimens examined—**INDIA, Arunachal Pradesh, West Kameng district**, Bomdila, Sela Pass alt. 4221 m, on bark, 12.11.2008, D.K. Upreti, U. Dubey, G.K. Mishra & R. Khare 08-009395/A, 08-009424 (LWG). **Sikkim, North Sikkim**, Tholung-Kissong track, alt. 2475-2700 m, on bark, G.P. Sinha 586, 588 (BSHC), Above Lachen, alt. 3000 m, on bark, 12.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-003770/A, 04-003805, 04-003981, 04-004138/A, 04-004180, 04-003781 (LWG); **East Sikkim**, Rechala surroundings, alt. 2700-2900 m, on bark, G.P. Sinha 1002 & 1003 (BSHC), **West Sikkim**, on way between Thangsing-Phedang track, alt. 3500 m, on bark, G.P. Sinha 867 (BSHC), Yoksum-Tsoka foot track, alt. 1800-3050 m, on bark, G.P. Sinha 202A (BSHC), Yoksum, on soil, 16.5.1960, M.N. Bose, 6278 (LWG-AWAS);. **Uttarakhand, Bageshwar district**, Phurkia to Pindari Glacier, near Mirtoli, alt. 3400 m, on bark, 11.6.1970, D.D. Awasthi 7695 (LWG-AWAS). **West Bengal, Darjeeling district**, Tiger Hill, alt. 2500 m, on soil, 17.4.1960, M.N. Bose 6237 (LWG-AWAS).

Remarks—*Nephromopsis ahtii* shares a similar morphology and ascospore with *N. ornata,* which differs in having a pale yellow medulla, lacking marginal cilia, and having ellipsoid (not globose) ascospores (Randlane & al. 1995).

Ecology & distribution—*Nephromopsis ahtii* commonly grows on trees, rarely on soil in open places. It grows on variety of trees including *Pinus* and *Quercus* at 2475–4300 m and is widely distributed in both lower temperate and temperate regions of Arunachal Pradesh, Sikkim, Uttarakhand, and West Bengal.

Nephromopsis awasthii G.K. Mishra, Nayaka & Upreti, **sp. nov.** Figs 3–4

MB 840586

Similar to *Nephromopsis nephromoides* but differs in having a smaller, grey to greenish thallus, larger apothecia, numerous pycnidia on upper and lower surfaces, a reticulately ridged to veined lower surface with pseudocyphellae, and filiform pycnoconidia.

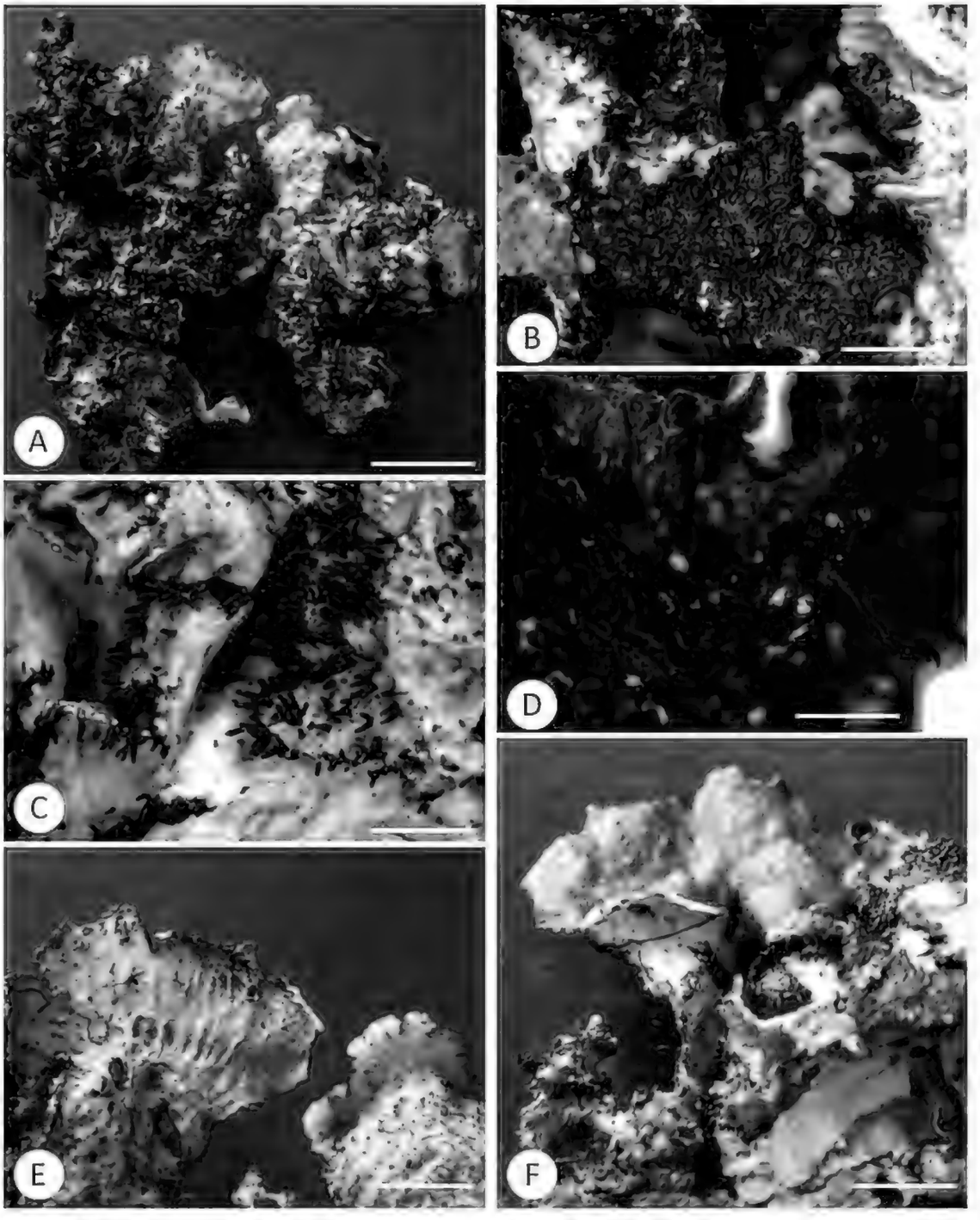


Fig. 3. ***Nephromopsis awasthii*** (holotype, LWG 18-037882a). A. habit; B. lower side of thallus with pseudocyphellae; C. marginal and laminal pycnidia; D. rhizines; E. upper side of apothecia with marginal pseudocyphellae; F. lower side of apothecia. Scale bars = 1 cm.

Type: India, Arunachal Pradesh, Tawang district, near Mungluam Gompa Monastery, near HSP-3, alt. 3656 m, on bark, 12.11.2019, R. Bajpai & R.R. Paul 19-037822 (**Holotype**, LWG 18-037882a; **isotype**, LWG 19-18-037882b).

Etymology: In honour of the distinguished Indian Lichenologist Dr. Dharani Dhar Awasthi (1922–2011).

Thallus foliose, corticolous, adnate to loosely attached to the substrate, horizontally spreading, ≤7 cm across; lobes rounded and convoluted, 0.5–1 cm wide, imbricate, black fibrils present along margins; upper surface greenish grey to yellowish grey, smooth to wrinkled, lobe margins sometimes black; isidia and soredia absent; lower surface white at center and pale brown to brownish to black towards margin, reticulately ridged and veined; pseudocyphellae present on lower surface on ridges or flat surface but not as plug like outgrowths or on the apothecial margins; rhizines sparse, long, white to brownish, simple or branched, ≤5 mm long; medulla white. Apothecia marginal on lower surface, nephromoid to semi-reniform, ≤15 mm in diam., exciple 2-layered, disc brown; hypothecium ≤90 µm long; asci clavate, 30–33 × 11–13 µm; ascospores colourless, globose to subglobose, 5–8.3 × 3.5–6.3 µm. Pycnidia numerous, on black emergent projections on marginal, laminal, and lower thallus surfaces; pycnoconidia filiform, 9–12.9 × 1–1.3 µm.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex; lichesterinic and protolichesterinic acids present in medulla in TLC.

Additional Specimens examined—**INDIA, Arunachal Pradesh, Tawang district**, near Nagala Lake HSP-1, alt. 4137 m, on bark, 13.11.2019, R. Bajpai & R.R. Paul 19-036791, 19-037818 (LWG).

Remarks—The new species *Nephromopsis awasthii* is characterized by a small thallus, numerous pycnidia and reticulately ridged lower surface, veined pseudocyphellae, and filiform pycnoconidia. *N. awasthii* strongly resembles *N. nephromoides* in thallus colour and large apothecia but *N. nephromoides* differs in lacking pycnidia and presence of oblong ascospores. *Nephromopsis awasthii* also resembles *N. ahtii* in having pycnidia on emergent projections and subglobose ascospores but differs in absence of marginal cilia and having larger apothecia measuring ≤15mm in diam. *Nephromopsis yunnanensis* is morphologically similar to *N. awasthii,* which differs in the lack of plug-like outgrowths on the lower surface. *Nephromopsis awasthii* shares small flat pseudocyphellae on the ridges of the lower surface with *N. laii,* which differs in having small apothecia and lacking pycnidia. The new species is also morphologically similar to *N. hypotrachyna* and *N. rhytidocarpa*, which are characterized by broadly ellipsoid ascospores, and the presence of salazinic and norstictic acids (Awasthi 1982). The combination of a small thallus, large apothecia,

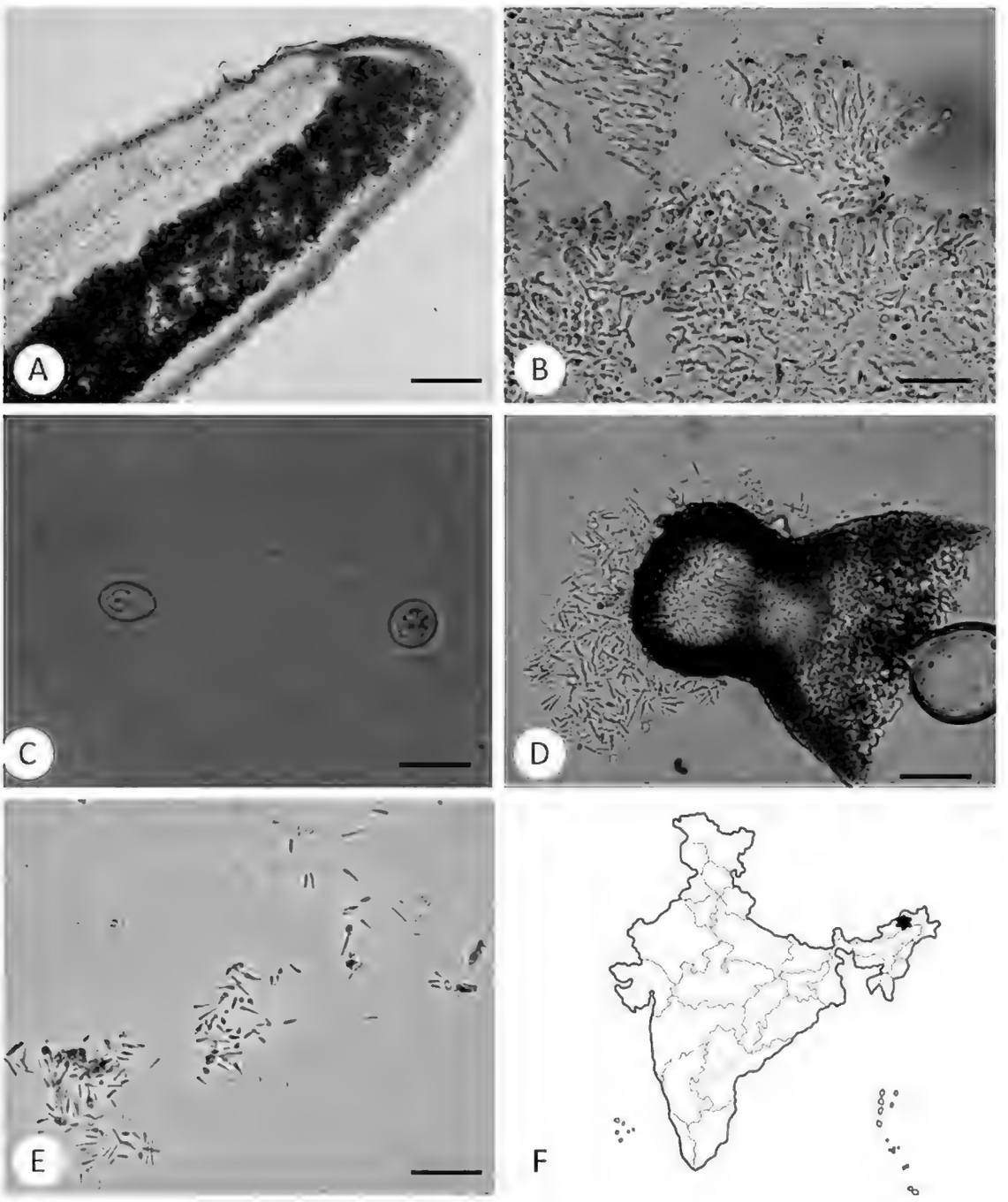


Fig. 4. ***Nephromopsis awasthii*** (holotype, LWG 18-037882a). A. section showing exciple; B. section showing asci; C. ascospores; D. pycnidia with conidia; E. pycnoconidia; F. Indian distribution. Scale bars = 1 cm.

frequent pycnidia, and filiform pycnoconidia in *Nephromopsis awasthii* is a unique set of characters of the new species.

Ecology & distribution—*Nephromopsis awasthii* grows on tree bark at 3635–4137 m and is so far known only from the surroundings of the type locality in Arunachal Pradesh, where it was growing in abundance.

Nephromopsis chlorophylla (Willd.) Divakar, A. Crespo & Lumbsch,
Fungal Diversity 84: 112 (2017)
≡ *Lichen chlorophyllus* Willd. in Humboldt, Fl. Frib. Spec.: 20 (1793)
≡ *Cetraria chlorophylla* (Willd.) Vain., Acta Soc. Fauna Fl. Fenn. 13(6): 7 (1896)
≡ *Tuckermannopsis chlorophylla* (Willd.) Hale in Egan, Bryologist 90: 164 (1987)

Thallus foliose, corticolous, loosely appressed, ≤3 cm across; lobes 2–3 mm wide, ± concave; margin ascending, undulate; upper surface yellowish brown, smooth; soredia present, soredia marginal, whitish farinose to grey granular; lower surface white to pale brown; pseudocyphellae absent; rhizines present, dark brown to blackish in the central region, remainder erhizinate and ±wrinkled; medulla white. Apothecia absent in the studied material. Pycnidia present, marginal, black; pycnoconidia bifusiform, 6 × 1 µm.

Chemistry—Medulla K–, C–, P–, KC–; protolichesterinic acid present in TLC.

Specimens examined—**INDIA, Uttarakhand, Chamoli district**, valley of flowers, alt. 3300 m, on bark, 20.9.2006, S. Rawat 06-007101 (LWG); **Uttarkashi district**, Gomukh area, right bank 6th moraine, alt. 4100 m, on bark, 5.6.1976, D.D. Awasthi & S.R. Singh 8555 (LWG-AWAS). **West Bengal**, **Darjeeling district**, Sandakhpoo, alt. 2900 m, on bark, 15.6.1967, D.D. Awasthi & M.R. Agrawal 67.381 (LWG-AWAS).

Remarks—In colour and thallus size, *Nephromopsis chlorophylla* closely resembles *N. ciliaris,* which differs in its ciliate margins, wider lobes, and presence of olivetoric acid in the medulla.

Ecology & distribution—*Nephromopsis chlorophylla* is a corticolous species occurring at 2900–4100 m in Sikkim and Uttarakhand.

Nephromopsis ciliaris (Ach.) Hue,
Nouv. Arch. Mus. Hist. Nat., Paris, 4 sér. 1: 216 (1899) Fig. 5a,b
≡ *Cetraria ciliaris* Ach., Lich. univ.: 508 (1810)
≡ *Lichen squarrosus* * *ciliaris* (Ach.) Lam., Encycl. Méth. Bot., Suppl. 3: 419 (1813)
≡ *Nephromopsis ciliaris* (Ach.) Hue, Nouv. Arch. Mus. Hist. Nat., Paris, 4 sér.1: 216 (1899)

Thallus foliose, corticolous, loosely adnate, horizontally spreading, ≤10 cm across; lobes 5–10 mm wide, rotund, margin crenate ciliate, pycnidiate; cilia black, simple, ≤7 mm long; pycnidia as densely or sparsely black fibrils; upper surface grey or yellowish to brown, smooth to wrinkled; soredia and isidia absent; lower surface white and brown below margin, rhizines present in central part of thallus, brown, simple, 1.5–3 mm long; pseudocyphellae absent; medulla white. Apothecia not seen. Pycnidia marginal, emergent projections; conidia citriform 5 × 7 µm.

Chemistry—Medulla K–, C–, KC+ reddish, P–; atranorin and olivetoric acids present in TLC.

Specimen examined—**INDIA, Karnataka, Bangalore district**, Bahhergatta Nazam-Kalu, alt. 980 m, on bark, 30.04.1979, D.D. Awasthi, D.K. Upreti & U. Mishra 79-273 (LWG-LWU).

Remarks—*Nephromopsis ciliaris,* which is similar in morphology and presence of cilia to *N. ahtii*, differs in its citriform pycnoconidia and the presence of atranorin and olivetoric acids as secondary metabolites and. *Nephromopsis chlorophylla,* which resembles *N. cilaris* in similar thallus colour and size, differs in the absence of cilia and the presence of protolichesterinic acid in thallus.

Ecology & distribution—*Nephromopsis ciliaris,* is rare in India and grows on trees at 980 m in the South Indian region in Karnataka. This species has been reported from other Asian countries, Europe, and North America (Gyelnik 1933; Brodo & al. 2001). This is the first record for India.

Nephromopsis cucullata (Bellardi) Divakar, Crespo & Lumbsch, Fungal Diversity 84: 112 (2017)

≡ *Lichen cucullatus* Bellardi, Osserv. Fenn. 1: 54 (1788)

≡ *Lobaria cucullata* (Bellardi) Hoffm., Deutschl. Fl.: 143 (1796)

≡ *Cetraria cucullata* (Bellardi) Ach., Methodus: 293 (1803)

≡ *Flavocetraria cucullata* (Bellardi) Kärnefelt & A. Thell, Acta Bot. Fenn. 150: 81 (1994)

Thallus foliose to subfruticose, terricolous, suberect to erect, ≤3 cm tall, subdichotomously branched, lobes ≤4 mm wide, canaliculate by connivent margins, upper surface yellow, basal part reddish, smooth; lacking isidia and soredia; lower surface pale yellow, smooth, minutely pseudocyphellate; marginal projections absent; rhizines present, simple; medulla white. Apothecia not seen. Pycnidia not seen.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex; lichesterinic and protolichesterinic acids present in TLC.

Specimens examined—**INDIA**, **Sikkim**, **North Sikkim**, Llonakha valley, Chhaber lake below Luna La, alt. 4600 m, on soil, G.P. Sinha 1606 (BSHC). **Uttarakhand**, **Bageshwar district**, Phurkia to Pindari Glacier, alt. 11500ft, on soil, 23.5.1950, D.D. Awasthi 781A (LWG-AWAS); **Uttarkashi district**, Gomukh area, right bank, 5th moraine, alt. 12500 ft, on bark, 5.7.1976, D.D. Awasthi & S.R. Singh 8493B (LWG-AWAS).

Remarks—*Nephromopsis cucullata* is easily distinguished by an involute, canaliculate, pale yellow to yellow, thin thallus. The species is morphologically

similar to *N. nivalis,* which differs in absence of secondary metabolites and flat thallus.

Ecology & distribution—*Nephromopsis cucullata* grows in association with mosses in alpine region at 4100–4600 m in the states of Sikkim and Uttarakhand.

Nephromopsis endoxanthoides (D.D. Awasthi) Randlane & Saag, Mycotaxon 44(2): 486 (1992)

≡ *Cetraria endoxanthoides* D. D. Awasthi, Bull. Bot. Surv. India 24: 9 (1982)

≡ *Cetreliopsis endoxanthoides* (D.D. Awasthi) Randlane & Saag in Randlane, Thell & Saag, Cryptog. Bryol. Lichenol. 16(1): 51 (1995)

Thallus corticolous, 4 cm across; lobes 5–10 mm wide; upper side greenish yellow with pseudocyphellae in the central part; isidia and soredia absent; lower side brown-black, sparsely pseudocyphellate and rhizinate; medulla yellow ochraceous. Apothecia marginal, 3–5(–6) mm in diam., disc reflexed upwards; ascospores 6–9.5 × 4.5–6 µm. Pycnidia marginal or laminal; pycnoconidia 5–6 × 1.5–2 µm.

Chemistry—Medulla K+ yellow, C–, KC–, P+ orange; fumarprotocetraric, protocetraric acids; traces of protolichesterinic and lichesterinic acids and unknown pigments present in TLC.

Remarks—*Nephromopsis endoxanthoides* is morphologically similar to *N. rhytidocarpa,* which is separated by a white medulla. The type specimen was not available for the present study, and the description above is based on Jagadeesh Ram & Sinha (2010).

Ecology & distribution— The corticolous *N. endoxanthoides* grows at 2250 m in West Bengal state of the Eastern Himalaya.

Nephromopsis hypotrachyna (Müll. Arg.) D.D. Awasthi, Lichenol. Indian Subcontinent: 15 (2000)

≡ *Cetraria hypotrachyna* Müll. Arg. Flora 74: 373 (1891)

≡ *Cetreliopsis hypotrachyna* (Müll. Arg.) Randlane & Saag, Mycotaxon 87: 482 (2003)

Thallus foliose, corticolous, adnate, ≤12 cm across; lobes 10 mm wide; upper surface greenish to yellow; pseudocyphellae present on both surfaces, on the upper surface in the submarginal zone occurring as white patches and often with black pycnidial projections and on the lower surface dark brown to black with sparse tiny grayish dots located on thallus ridges, pseudocyphellate; isidia and soredia absent; rhizines present, black to brown; medulla white. Apothecia marginal, ≤6 mm in diam., with dark brown disc; asci clavate, 30–33 × 11–13 µm; ascospores broadly ellipsoid,

7–8 × 4–6 µm. Pycnidia marginal and laminal on both surfaces; pycnoconidia bifusiform, 4×1 µm.

Chemistry—Medulla K+ yellow-brown, C–, KC–, P+ orange-red; salazinic and norstictic acids present in TLC.

Specimen examined —**INDIA, Manipur**, on twigs, G. Watt 6949 (Holotype: BM).

Remarks—*Nephromopsis hypotrachyna* resembles *N. rhytidocarpa,* which differs in having a smooth thin thallus bearing pseudocyphellae on both surfaces. No Indian herbarium specimen was traceable. Therefore, the description is based on Awasthi (1982).

Ecology & distribution—This is a corticolous species known exclusively from its type locality at 3000 m in the state of Manipur.

Nephromopsis isidioidea (Räsänen) Randlane & Saag, Mycotaxon 44: 487. (1992)

≡ *Cetraria wallichiana* var. *isidioidea* Räsänen, Arch. Soc. Zool. Bot. Fenn. Vanamo 5(1): 25 (1950)

≡ *Cetraria isidioidea* (Räsänen) D.D. Awasthi, Bull. Bot. Surv. India 24: 10 (1983)

Thallus foliose, corticolous, loosely adnate, horizontally spreading ≤5.5 cm across; lobes 3–20 mm wide; upper surface yellowish grey to brownish, reticulately scrobiculate with fibrils on ridges and along margins; isidia and soredia lacking; lower surface brown to black, lamellate rugose with peg like outgrowths; pseudocyphellae present on ridges and on plug-like outgrowths; rhizines present; medulla yellow to ochraceous. Apothecia (seen only on isotype specimen) marginal, peltate to nephromoid, ≤6 mm in diam., disc dark brown, exciple thin; asci clavate 20–35 × 8–10 µm, 8-spored; ascospores colourless, simple, ellipsoid, 8–10 × 2–3 µm. Pycnidia not seen.

Chemistry—Medulla K+ yellow, C–, P–, KC–; secalonic, lichesterinic, and protolichesterinic acids present in medulla in TLC.

Specimens examined—**INDIA, Sikkim, North Sikkim**, Thangu, Chepta valley surroundings, alt. 3900 m, on bark, G.P. Sinha 1625 (BSHC). **West Bengal, Darjeeling district**, Rimbick to Sandakphoo, alt. ca 2700 m, on dead tree stump, June 1948, D.D. Awasthi 179 (LWG-AWAS).

Remarks—*Nephromopsis isidioidea* resembles *N. endocrocea* Asahina in absence of soredia and isidia and K+ yellow medulla but differs in having a strongly rugose and reticulate thallus and laminal pseudocyphellae on ridges.

Ecology & distribution—The corticolous *N. isidioidea* grows at 2700–3900 m in Sikkim and West Bengal states of the eastern Himalayas.

Nephromopsis laii (A. Thell & Randlane) Saag & A. Thell, Bryologist 100: 111 (1997)

≡ *Cetrariopsis laii* A. Thell & Randlane, Cryptog. Bryol. Lichénol. 16: 46 (1995)

Thallus foliose, corticolous, adnate, ≤12 cm across; lobes convolute, rounded, ≤10 mm wide; upper surface greenish yellow, lacking fibrils along margins; isidia and soredia lacking; lower surface brownish; pseudocyphellate on lamellae and plug-like outgrowths; rhizines short; medulla white. Apothecia marginal, round to reniform, ≤5 mm in diam., exciple two- layered; ascospores 5–9 × 2.5–4.5 µm. Pycnidia not seen.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex; lichesterinic and protolichesterinic acids present in medulla in TLC.

Specimens examined—**INDIA, Arunachal Pradesh, Tawang district**, Nagala near Nagula lak, alt. 4137 m, on bark, 15.6.2015, R. Bajpai 15-026550, 15-026552 (LWG). **Andaman Islands, Middle Andaman**, Long Island, sea level, on bark, 27.3.1961, A. Singh & party 89414 (LWG). **Himachal Pradesh, Kullu district**, Great Himalayan National Park, Shilt, alt. 2800 m, on bark, 4.11.2002, S. Nayaka & R. Srivastava 02-00581/B (LWG), on way to Shilt to Gumtaro, alt. 3000 m, on bark, 6.9.1999, D.K. Upreti 99-53632 (LWG), enroute to Jalori lake, alt. 3145 m, on bark, 3.5.2008, D.K. Upreti & Y. Joshi s.n. (LWG), Pardi, alt. 3140 m, on bark, 5.11.2002, S. Nayaka & R. Srivastava 02-000519 (LWG); **Shimla district**, Rohodu Larote, enroute to Chanshal pass, alt. 3285 m, on bark, 26.8.2016, R. Bajpai 16-030301 (LWG). **Sikkim, near Karpong,** alt. 8000ft, on bark, May 1947, D.D. Awasthi 173, 174 (LWG-AWAS). **Uttarakhand, Bageshwar district**, Dhakuri ridge, alt. 8000 ft, on bark, 8.6.1970, D.D. Awasthi 7568 (LWG); **Chamoli district**, Between Madmaheshwar to Gondar, alt. 3000 m, on bark, 19.9.1975, A. Singh & M. Ranjan 107020/B, 107020/A, 106994 (LWG), Mandakini river valley, on way from Gaunikund to Rambara, alt. 2800 m, on bark, 18.9.1976, K. Dange, 76.137 (LWG-AWAS), Joshi math, Auli, ITBP, Gosu Top, near Nandadevi temple, on bark, August 2003, S.M. Singh, 03-001854 (LWG), Nanda Devi Reserve, 1 km before Belta, alt. 3200 m, on bark, 6.6.2008, S. Rawat 08-011062/A (LWG), Auli, on bark, Aug 2003, S.M. Singh 03-001854 (LWG); **Dehradun district**, Chakrata near Deoban, alt. 3000 m, on bark, 3.7.1951, D.D. Awasthi 960 (LWG-AWAS); **Pithoragarh district**, Kalamuni, alt. 26700 m, on bark, 18.6.1973, A. Singh 102677 (LWG), between Lilam to Bugdiyar, Rana Man Singh Top, alt. 2700 m, on bark, 25.6.1973, A. Singh 102772 (LWG), Nain Singh Top, alt. 2700 m, on bark, 15.9.1966, D.K. Upreti & J. Tandon L104619 (LWG), Narayan Swami Ashram, alt. 3000 m, on bark, 2.11.2009, D.K. Upreti, G.K. Mishra & R. Khare 09-013407 (LWG); **Uttarkashi district**, Govind Wildlife Sanctuary, enroute to Judatal near nursery, alt. 2312 m, on bark, 5.10.2013, R. Bajpai 13-02005/B, 13-020005, 13-020048/A (LWG), Judatal to Kedarkantha, alt. 2871 m, on bark, 6.10.2013, R. Bajpai 13-020018/E, 13-020066, 13-020016/A (LWG), Talahuti 3 km from Taluka, alt. 2155 m, on bark, 5.4.2013, R. Bajpai 13-01998, 13-019465 (LWG), 4 km before Sankari enroute to Natwar, alt. 2400 m, on bark, 7.11.2012, R. Bajpai 12-018337, 12-018864 (LWG), around Judatal, alt. 3400 m, on bark, 5.11.2012, R. Bajpai, 12-018951, 12-018976

(LWG), Judatal to Kedarkantha, alt. 3400 m, on bark, 6.10.2013, R. Bajpai 13-020116, 13-020068, 13-019875, 13-020018 (LWG), enroute to Har-ki-Dun, from Osla, alt. 3205 m, on bark, 11.6.2012, D.K. Upreti & R. Bajpai 12-016148 (LWG).

Remarks—*Nephoromopsis laii* is similar in ascospore shape and size to *N. rugosa*, which differs in its smooth or slightly rugose thallus and different chemistry.

Ecology & distribution—*Nephoromopsis laii* grows on bark at 2100–3500 m and is widely distributed in Arunachal Pradesh, Andaman Islands, Himachal Pradesh, Sikkim, and Uttarakhand.

Nephromopsis leucostigma (Lév.) A. Thell & Randlane, Mycol. Progr. 4: 311 (2005)

≡ *Cetraria leucostigma* Lév., in Jacquemont, Voy. Inde 4: 180 (1844)

≡ *Flavocetrariella leucostigma* (Lév.) D.D. Awasthi, Comp. Macrolich. India, Nepal & Sri Lanka: 162 (2007)

= *Cetraria sikkimensis* Räsänen, Arch. Soc. Zool. Bot. Fenn. Vanamo 5(1): 25 (1950) ["1951"]

Thallus fruticose, suberect to erect, corticolous or terricolous, 3–8 cm tall, irregularly to dichotomously branched; lobes widening upwards, 5–10 mm wide, plane to involute, subcanaliculate towards apices, undulating along the margins; upper surface yellow to brown to pale brown, smooth, 0.2–0.4 mm, black fibrils present at margin; isidia and soredia absent; lower surface pale brown to dark brown colour, smooth to slightly lacunose-rugose, pseudocyphellae present, white, depressed, rounded to irregular, depressed, brown rimmed present when thallus yellow, ≤0.1–0.5 mm across; rhizines present, black, in clusters; medulla white. Apothecia very rare (seen only isotype of *C. sikkimensis*), marginal, peltate to subnephromoid, round to oblong, 10 × 6 mm in size, disc brown, smooth; asci 8-spored; ascospores hyaline simple, ovoid, 8–9 × 6 µm. Pycnidia not seen.

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex; lichesterinic and protolichesterinic acid present in medulla in TLC.

Specimens examined—**INDIA, Himachal Pradesh, Kullu district**, Great Himalayan National Park, Soupdhar, alt. 3900 m, on bark, 7.09.1999, D.K. Upreti 99-53676 (LWG); **Shimla district**, Shimla, on soil, October 1978, A. Singh L18205 (LWG). **Uttarakhand, Bageshwar district**, Mirtoli plain near Pindari, alt. 3750 m, on soil, 27.5.1972, A. Singh 91986 (LWG), on way to Phurkia to Mirtoli, alt. 2900 m, on bark, D.D. Awasthi 7744 (LWG-AWAS); **Uttarkashi district**, Gomukh area right bank, 5th Moraine, alt. 4200 m, on soil, 4.6.1976, D.D. Awasthi & S.R. Singh 8493A, 8473 (LWG-AWAS).

Remarks—*Nephromopsis leucostigma* is morphologically close to *N. melaloma,* which differs in its yellowish to grey (not brown) thallus and indistinct pseudocyphellae.

Ecology & distribution—*Nephromopsis leucostigma* is terricolous and occurs at 2500–4200 m in the Western Himalayan states Himachal Pradesh and Uttarakhand.

Nephromopsis laureri (Kremp.) Kurok., J. Jap. Bot. 66: 156 (1991)

≡ *Cetraria laureri* Kremp., Flora 34: 673 (1851)

≡ *Tuckneraria laureri* (Kremp.) Randlane & A. Thell, Acta Bot. Fenn. 150: 149 (1994)

Thallus foliose, corticolous, ≤5 cm across; lobes 2–5 mm wide, imbricate, margin rounded to weakly crenate, with minute black fibrils; upper surface yellowish to grey, involute, smooth to scrobiculate; soredia present, soredia marginal, discontinuous, farinose to granular, intermittently present between minute fibrils, isidia absent; lower surface pale brown or concolorous with upper surface, slightly rugose; pseudocyphellae present, white; rhizines sparse, concolorous with upper surface, ≤1.0 mm long; medulla white. Apothecia not seen. Pycnidia not seen

Chemistry—Medulla K–, C–, P–, KC–; usnic acid in cortex; lichesterinic and protolichesterinic acids present in TLC.

Specimens examined—**INDIA, Arunachal Pradesh, West Kameng district**, Sela Pas, alt. 4221 m, on bark, 12.11.2008, D.K. Upreti, U. Dubey & G.K. Mishra 08-009413 (LWG). **Himachal Pradesh**, G.H.N.P., Jubkutar Thach, alt. 2900 m, on bark, 10.6.1999, D.K. Upreti L65184 (LWG). **Sikkim, North Sikkim**, Shingba Rhododendron Sanctuary, alt. 3350 m, on bark, G.P. Sinha 1067 (BSHC), 2 km before Shingba Rhododendron Sanctuary, near Yumthang, alt. 3500 m, on bark, 15.08.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004113, 04-004138/B, 04-004129 (LWG), Tholung, Gumpa surrounding forest, alt. 2500 m, on bark, G.P. Sinha 623 (BSHC); **West Sikkim**, Near Bakhim, alt. 2500–2700 m, on bark, G.P. Sinha 706 (BSHC), Phedang-Dzongri foot track, alt. 3900–4025 m, on rock, G.P. Sinha 238A (BSHC), Thangsing Lampokhari foot track, 3 km point, alt. 3500 m, rock, G.P. Sinha 851 (BSHC), near Yumthang, alt. 3800 m, on bark, 15.08.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004180, 04-003967 (LWG), Kalep before Thangu, alt. 3900 m, on bark, 12.08.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-003836/A (LWG), 4 km after Lachung towards Yumthang, alt. 3100 m, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004051 (LWG), Chubuk above Thangu, alt. 4100 m, on bark, 13.08.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-003928 (LWG). **Uttarakhand, Bageshwar district**, near Dhakuri ridge, alt. 2800 m, on *Rhododendron* bark, 08.06.1970, D.D. Awasthi 7569 (LWG-AWAS); 23.05.1972, A. Singh L89335 (LWG).

Remarks—In the presence of white pseudocyphellae and colour of the upper surface, *N. laureri* closely resembles *N. togashii*, which differs in having isidia and lacking sorediate margins.

Ecology & distribution—*Nephromopsis laureri* is terricolous and occurs at 2500–4100 m in Arunachal Pradesh, Himachal Pradesh, Sikkim, and Uttarakhand.

Nephromopsis melaloma (Nyl.) A. Thell & Randlane,
Mycol. Progr. 4:311 (2005)
≡ *Platysma melalomum* Nyl., Syn. Meth. Lich. 1: 303 (1860)
≡ *Cetraria melaloma* (Nyl.) Kremp., Verh. K. K. Zool. Bot. Ges. Wien.18: 315 (1868)
≡ *Flavocetrariella melaloma* (Nyl.) D.D. Awasthi, Comp. Macrolich. India, Nepal & Sri Lanka: 163 (2007)

Thallus fruticose, suberect to erect, corticolous or terricolous, 2–3.5 cm tall, irregularly to dichotomously branched; lobes 2–5 mm wide, plane to involute subcanaliculate on upper side, margin undulate; upper surface yellow to yellowish grey to mottled brown, 0.1–0.2 mm long black fibrils at the margin; isidia and soredia absent; lower surface pale, pseudocyphellae round, brown rimmed, ≤0.5 mm acros. Apothecia not seen. Pycnidia not seen.

Chemistry—Medulla K–, C–, KC–, P–; usnic acid in cortex; lichesterinic and protolichesterinic acids and rarely stictic acid present in medulla in TLC.

Specimens examined—**INDIA, Sikkim, North Sikkim,** Lachung, on rock over soil, 27.4.1975, V.S. Sharma & M. Ranjan 76760 (LWG). **Uttarakhand, Bageshwar district**, Phurkia to Pindari Glacier near Mirtoli, alt. 3400 m, on soil, 11.6.1970, D.D. Awasthi 7695, 7775 (LWG-AWAS).

Remarks—*Nephromopsis melaloma* resembles *N. komarovii* (Elenkin) J.C. Wei, which is a saxicolous species.

Ecology & distribution—The species grows on soil in moist places in the subalpine zone at 3500 m in Sikkim and Uttarakhand.

Nephromopsis morrisonicola M.J. Lai,
Quarterly Journal of the Taiwan Museum 33(3 & 4): 223 (1980) Fig. 5c,d

Thallus foliose, corticolous, loosely adnate, ≤15 cm in diam.; lobes ascending, 8–15 mm wide; upper surface yellow, smooth; soredia and isidia absent; lower surface black, margin of lobes brown; pseudocyphellae present; rhizines present, brownish to black, simple or branched, sparsely scattered; medulla white. Apothecia not seen. Pycnidia present, marginal and laminal, emergent projections; pycnoconidia bifusiform 5.5 × 2.5 µm.

Chemistry—Medulla K–, C–, KC–, P–; usnic acid in cortex; lichesterinic and protolichesterinic acids are present in TLC.

Specimens examined—**INDIA, Arunachal Pradesh, Tawang district**, Ptso-lake, alt. 3982 m, on bark, 15.06.2015, R. Bajpai 15-026516 (LWG), Sela Pass, alt. 4135, on bark, 17.06.2015, R. Bajpai 15- 026516/A, 15-037824 (LWG). **Sikkim, South Sikkim district**, Kupup Gnathang (HSP-3), alt. 3700 m, on bark, 24 April 2014, R. Bajpai 14-024953 (LWG).

Remarks—In its black lower surface, *N. morrisonicola* closely resembles *N. ornata,* which differs in having a yellow medulla and fumarprotocetraric and secalonic acids.

Ecology & distribution—*Nephromopsis morrisonicola* is corticolous, occurring at 3702–4135 m in Arunachal Pradesh and Sikkim. This species has wide distribution, previously known from China, Indonesia, Nepal, Philippines, Papua New Guinea, and Taiwan (Randlane & Saag 1998). This is the first report from India.

Nephromopsis nephromoides (Nyl.) Ahti & Randlane,
Cryptog. Bryol. Lichénol. 19(2-3): 183 (1998)
≡ *Platysma nephromoides* Nyl., Flora 52: 442 (1869)
≡ *Cetraria nephromoides* (Nyl.) D.D. Awasthi, Bull. Bot. Surv. India 24 (1-4): 11 (1983)

Thallus foliose, corticolous, adnate to loosely attached at the central part of the thallus, horizontally spreading, ≤20 cm across; lobes rounded and convoluted ≤2–4 cm wide, imbricate, lacking fibrils along margins; upper surface greenish grey to yellowish grey, reticulate rugose, lacunose; isidia and soredia absent; lower surface pale yellow to brownish, reticulate rugose, lamellate; pseudocyphellae present on surface or on lamellate ridges but not as a plug-like outgrowths; rhizines sparse, short, brownish, simple ≤2 mm long; medulla white. Apothecia marginal on lower side, nephromoid, ≤10 mm in diam., exciple two layered, disc brown; ascospores colourless, oblong to ellipsoid 7–9 × 3.5 µm. Pycnidia not seen.

Chemistry—Medulla K–, C–, KC–, P–; usnic acid in cortex; lichesterinic and protolichesterinic acids present in the medulla in TLC.

Specimens examined—**INDIA, Arunachal Pradesh, West Kameng district**, Barts, alt. 2727 m, on bark, 22.9.2012, R. Debnath 12-017794 (LWG). **Sikkim, Mangan district**, above Lachen, alt. 3000 m, on bark, 12.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004127 (LWG). **Uttarakhand, Bageshwar district**, Dhakuri, alt. 3000 m, on bark, 22.5.1972, A. Singh 89323, 89338 (LWG), Dhakuri ridge, alt. 3000 m, on bark, 19.5.1950, D.D. Awasthi & A.M. Awasthi 642B (LWG-AWAS), Loharghet to Dhakuri, alt. 2800 m, on bark, 18.5.1950, D.D. Awasthi & A.M. Awasthi 624 (LWG-AWAS); **Chamoli district**, Auli, alt. 3000 m, on bark, 14.3.2005,

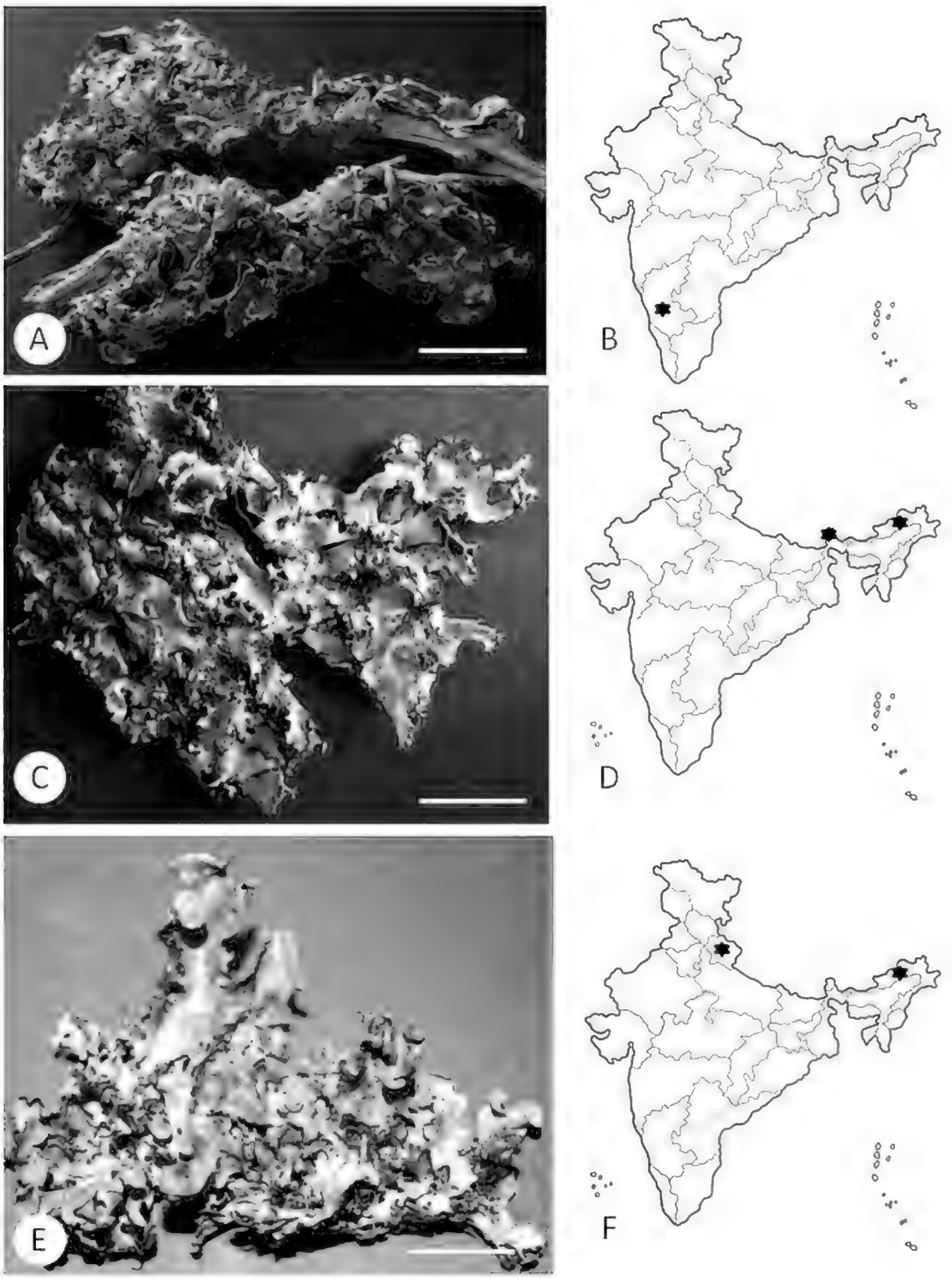


Fig. 5. ***Nephromopsis ciliaris*** (LWG-LWU 79-273). A. habit; B. Indian distribution. ***Nephromopsis morrisonicola*** (LWG 15-026516.) C. habit; D. Indian distribution. ***Nephromopsis pseudocomplicata*** (LWG 19-037823.) E. habit; F. Indian distribution. Scale bars: A, C, E = 1 cm.

M. Rao 05-005007, 05-005002 (LWG), 6.9.1991, D.K. Upreti 202327 (LWG), Nanda Devi Biosphere Reserve, 1 km before Belta, on bark, 6.6.2008, S. Rawat 08-011062/B (LWG); **Pithoragarh district**, Munsiyari, on way to Khaliya top, alt. 2900 m, on bark, 29.6.1993, D.K. Upreti 212923 (LWG), 17.11.2006, Y. Joshi & R. Bajpai 06-007075, 06-006906 (LWG), Kalamuni, alt 2670 m, on bark, 18.6.1973, A. Singh 102673 (LWG), Birthi falls, on rock, 29.10.2009, D.K. Upreti & G.K. Mishra 09-012440 (LWG). **West Bengal, Darjeeling district**, Batasi to Pahnajua, alt. 3000 m, on bark, 3.5.1960, M.N. Bose 60.65 (LWG-AWAS), on way from Sandakhpoo to Phalut, alt. 4000 m, on bark, 16.6.1967, D.D. Awasthi & M.R. Agrawal 67.442 (LWG-AWAS), 6.6.1960, M.N. Bose 60.151 (LWG-AWAS), Rinsluck to Sandakhpoo, alt. 3000 m, on bark, June 1948, D.D. Awasthi 188 (LWG-AWAS).

Remarks—*Nephromopsis nephromoides,* which shares a general thallus morphology with *N. laii,* differs in having a smooth to slightly wrinkled, medium to large thallus and flat to concave pseudocyphellae.

Ecology & distribution—*Nephromopsis nephromoides* is corticolous and is widely distributed at 2700–4000 m in Arunachal Pradesh, Uttarakhand, and the Darjeeling district of West Bengal.

Nephromopsis nivalis (L.) Divakar, A. Crespo & Lumbsch,
Fungal Diversity 84: 113 (2017)
≡ *Lichen nivalis* L., Sp. pl. 2: 1145 (1753)
≡ *Flavocetraria nivalis* (L.) Kärnefelt & A. Thell, Acta Bot. Fenn. 150: 84 (1994)

Thallus fruticose, terricolous, flat to erect, ≤5 cm across; lobes ≤7 mm wide; upper surface yellow to dark yellow, lacking marginal papillae; isidia and soredia absent; lower side foveolate, with minute pseudocyphellae; medulla white. Apothecia not seen. Pycnidia not seen.

Chemistry—Medulla K– C–, KC–, P–; no lichen substance present in TLC.

Specimens examined—**INDIA, Uttarakhand, Chamoli district**, on way from Mana to Vasudhara Falls, alt. 3340 m, on soil, 21.8.2007, D.K. Upreti & S. Nayaka 07-01032 (LWG), Nanda Devi Biosphere Reserve, N.W. Part, on soil, April-May 1993, H.R. Negi 1993 (LWG); **Uttarkashi district**, Gomukh area, right bank, 5th moraine, alt. 12500 ft, on bark, 5.7.1976, D.D. Awasthi & S.R. Singh 8473 (LWG-AWAS).

Remarks—*Nephromopsis nivalis* is unique in the genus in having a yellow thallus and strongly wrinkled lobes. It shares a yellow-coloured upper surface with *Cetraria ambigua,* which differs in having a flat upper surface and lacking foveolate lobes.

Ecology & distribution—*Nephromopsis nivalis* is terricolous, growing on soil over rock at 3300–4200 m. In India the species has a restricted distribution in Uttarakhand.

Nephromopsis ornata (Müll. Arg.) Hue,

Nouv. Arch. Mus. Hist. Nat., ser. 4, 2: 90 (1900)

≡ *Cetraria ornata* Müll. Arg., Nouvo Giorn. Bot. Ital. 23: 122 (1891)

= *Nephromopsis delavayi* Hue, Nouv. Arch. Mus. Hist. Nat., sér 4, 1: 219 (1899)

≡ *Cetraria delavayi* (Hue) M. Satô, Nov. Fl. Japon. 1: 48 (1939)

Thallus foliose, corticolous, loosely adnate, ≤16 cm in diam.; lobes ascending, 10–15 mm wide; upper surface grey to yellowish, smooth or slightly wrinkled; soredia and isidia absent; lower surface brown to black, reticulated; pseudocyphellae present, white on ridges or at marginal part; rhizines present, brownish to black, simple, sparsely scattered; medulla pale yellow. Apothecia rounded or reniform, disc brown, 20 mm diam.; asci narrowly clavate 15–35 × 6–10 µm, ascospores oblong 7–8 × 4–5 µm. Pycnidia present, marginal and laminal on emergent projections; pycnoconidia bifusiform 5 × 1.5 µm.

Chemistry—Medulla K+ deep yellow, C–, KC–, P–; usnic present in cortex; fumarprotocetraric and secalonic acids present in medulla in TLC.

Specimens examined—**INDIA, Himachal Pradesh, Kullu district,** G.H.N.P., Jubkutar Thach, alt. 2900 m, on bark, 10.6.1999, D.K. Upreti L65173 (LWG). **Sikkim, South Sikkim,** between Thangsing & Pradong, alt. 3500 m, on bark, 17.09.1995, G.P. Sinha 867 (LWG), Lachung, 27.4.1975, V.S. Sharma & M. Ranjan 76771 (LWG). **Uttarakhand, Pithoragarh district**, Munsiyari Nain Singh Top, alt. 2700 m, on bark, 15.9.1996, Upreti & Tandon L104805 (LWG). **West Bengal, Darjeeling district**, Batasi to Palujua, alt. 2500 m, on soil, June 1948, D.D. Awasthi 175 (LWG-AWAS).

Remarks—*Nephromopsis ornata* is morphologically close to *N. endocrocea,* which has a different chemistry and a white (not pale yellow) medulla.

Ecology & distribution—The species is corticolous and occurs at 2500–3500 m in Himachal Pradesh, Sikkim, Uttarakhand, and West Bengal.

Nephromopsis pallescens (Schaer.) Y.S. Park, Bryologist 93: 122 (1990)

≡ *Cetraria pallescens* Schaer. in Moritzi, Syst. Verz.: 129 (1845)

= *Sticta wallichiana* Taylor, London J. Bot. 6: 177 (1847)

≡ *Cetraria wallichiana* (Taylor) Müll. Arg., Flora 71: 139 (1888)

Thallus foliose, corticolous, loosely attached by central lower part, 8–16 cm across; lobes rounded, 2–10 mm wide, imbricate, margin smooth to dissected, undulate, convoluted, lacking black fibrils; upper surface greenish yellow to grey, scrobiculate-rugose; isidia and soredia absent; lower surface pale to brownish, scrobiculate to lamellate; pseudocyphellae on lamellae and plug-like outgrowths; rhizines sparse, brownish, 0.5–2 mm long; medulla white. Apothecia numerous, marginal or laminal to submarginal, dense, 0.5–3 mm in diam.; margin sometimes excluded, smooth to crenulate; ascospores 5–10 × 2–5 µm. Pycnidia not seen.

Chemistry—Medulla K–, C–, KC+ red, P–; usnic acid in cortex; lichesterinic, protolichesterinic, alectoronic, and alpha-collatolic acids present in TLC.

Specimens examined—**INDIA, Andaman Island**, Middle Andaman Long Island, sea level, on bark, A. Singh 89407 (LWG). **Himachal Pradesh, Kullu district**, Great Himalayan National Park, Shilt, alt. 2800 m, on bark, 4.11.2002, S. Nayaka & R. Srivastava 02-000581/A (LWG), on way to from Shilt to Gumtaro, alt. 3600 m, on bark, 6.9.1999, D.K. Upreti 99-53643, 99-54058/A (LWG), on way to Dhela to Lapah, alt. 3000 m, on bark, 8.9.1999, D.K. Upreti 99-54052, 99-54016, 99-54017 (LWG), Ecodevelopment zone Khanti, alt. 2800 m, on bark, 21.6.2004, R. Srivastava 04-003145 (LWG); **Shimla district**, Narkanda, Hatu peak, alt. 3360 m, on bark, 14.5.2002, S. Nayaka & R. Srivastava 02-81560, 02-81598 (LWG). **Sikkim, North Sikkim**, Jouri, alt. 4300 m, on bark, 23.5.1960, M.N. Bose 60.131, 63.130 (LWG-AWAS), Lachung, on bark, 27.4.1975, V.S. Sharma & M. Ranjan 76769, 76781 (LWG), Phingar, between Lachen and Thangu, alt. 3500 m, on bark, 14.7.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004033 (LWG). **Uttarakhand, Bageshwar district**, Dhakuri to Khati, alt. 2833 m, on bark, 9.6.1970, D.D. Awasthi 7619 (LWG-AWAS), 22.5.1997, D.K. Upreti, S. Chatterjee & J. Tendon L69017, L68952, L69040, L68959 (LWG), Khati to Dwali, alt. 2550 m, on bark, 24.5.1972, A. Singh 89381/A, 89316, 89381/B, 89310 (LWG), 25.9.1980, P.C. Pande 80-54315, 80-54320 (LWG), Dhakuri to Pindari, alt. 2540 m, on bark, 23.5.1972, A. Singh 89355, 89341 (LWG), on way to Sunderdhunga Glacier, between Loharkhet to Dhakur, 5 km before Dhakuri, alt. 3000 m, on bark, 11.9.1995, D.K. Upreti & Tandon 213374 (LWG), Dhakuri ridge (on way to Pindari), alt. 3300 m, on bark, 19.5.1950, D.D. Awasthi & A.M. Awasthi 640 (LWG-AWAS), 8.6.1970, D.D. Awasthi 7570, 7592 (LWG-AWAS), From Dwali to Phurkia, alt. 3210 m, on bark, 13.5.2007, S. Joshi & Y. Joshi 07-0010072 (LWG); **Chamoli district**, Badrinath between Vasundhara & Bhagirathi Glacier, alt. 3900-4500 m, on soil, 9.9.1991, D.K. Upreti s.n. (LWG), between Wan to Bhuna, on bark, 23.10.1967, A. Singh 91134, 91571, 90378 (LWG), Joshi Math to Auli, on bark, Aug 2003, S.M. Singh 03-001853 (LWG), Auli Bugyal to Wan, alt. 2850 m, on bark, 26.10.1967, A. Singh 91101 (LWG), Madmaheshwar & Gondar, alt. 3000 m, on bark, 19.9.1975, A. Singh & M. Ranjan 107009/A, 106938, 107047,106941 (LWG); **Dehradun district**, Chakrata Hills, Deoban, near Dak Banglow, alt. 3066 m, on bark, 22.6.1976, D.D. Awasthi & M. Joshi 76.83 (LWG-LWU), 3.7.1951, D.D. Awasthi 961 (LWG-AWAS), 30.10.1980, S. Chandra, s.n. (LWG); **Pithoragarh district**, Munsiyari, Kalamuni, alt. 3000-3200 m, on bark, 24.5.1988, B.S. Kholia 18476 (LWG), 18.6.1973, A. Singh 102682, 102676, 102681 (LWG), Khuliya Top, alt. 3000 m, on bark, 31.10.2009, D.K. Upreti & G.K. Mishra 09-013494 (LWG), Dharchula Sobhala forest above Kartu village, alt. 3150 m, on bark, 27.9.1990, D.K. Upreti & G. Hariharan 202217 (LWG); **Rudraprayag district**, Chopta, alt. 2700 m, on bark, 17.4.2006, D.K. Upreti & Balwant Kumar 06-005972 (LWG); **Uttarkashi district**, between Phool Chetti-Narad Chetti A. Singh & Rampher 77508, 76100/A (LWG). **West Bengal, Darjeeling district**, Batasi to Paluanjua, alt. 2400 m, on bark, 3.5.1960, M. N. Bose 60.62, 60.63 (LWG-AWAS), June 1949, D.D. Awasthi 180 (LWG-AWAS).

Remarks—*Nephromopsis pallescens* var. *pallescens* shares a closely similar thallus morphology with *N. pallescens* var. *citrina* (Taylor) A. Thell & Randlane, which differs from the typical variety in having a light to dark yellow thallus and small white dots of pseudocyphellae and lacking small numerous laminal apothecia.

Ecology & distribution—The typical variety grows abundantly on bark of different trees in open forest at 2400–4500 m. *Nephromopsis pallescens,* which is one of most common *Nephromopsis* species in India, occurs in Andaman Island, Himachal Pradesh, Sikkim, Uttarakhand, and West Bengal.

Nephromopsis pseudocomplicata (Asahina) M.J. Lai,
Quarterly Journal of the Taiwan Museum 33(3 & 4): 224 (1980) Fig. 5e,f
≡ *Cetraria pseudocomplicata* Asahina, J. Jap. Bot. 12: 804 (1936)
≡ *Tuckneraria pseudocomplicata* (Asahina) Randlane & Saag, in Randlane, Saag, A. Thell & Kärnefelt, Acta Bot. Fenn. 150: 150 (1994)

Thallus foliose, corticolous, loosely attached, 1–12 cm in diameter; lobes rounded ≤7 mm wide, ciliate; cilia scattered; upper surface greenish brown; soredia and isidia absent; lower surface white to pale brown; rhizines laminal to marginal, simple, black, ≤4 mm long; pseudocyphellae on lower side, numerous, rounded to irregular, small, whitish to pale brown, laminal or submarginal; medulla white. Apothecia marginal, rounded to reniform, 3–7 mm in diameter, reddish or brownish disc; asci clavate, 30–35 × 12–14 µm, ascospores hyaline subglobose 5–7 × 4–6 µm. Pycnidia common, marginal to laminal emergent; pycnoconidia bifusiform, 3.5–5 × 1–1.5 µm.

Chemistry—Medulla K–, C–, KC+ red, P–; usnic acid in cortex; alectoronic, lichesterinic, and protolichesterinic acids are present in TLC.

Specimens examined—**INDIA, Arunachal Pradesh, Tawang district**, Ptso-lake, alt. 3982 m, on bark, 15 June 2015, R. Bajpai 15-026520 (LWG), Sela Pass, alt. 4135 m, on bark, 17 June 2015, R. Bajpai 15-026526 (LWG), Near Mungulam Gompa Monestry, near HSP-3, alt. 3656 m, on bark, 12.11.2019, R. Bajpai & R.R. Paul 19-037823 (LWG).

Remarks—*Nephromopsis pseudocomplicata* closely resembles *N. laii* and *N. rugosa* in having similar secondary metabolites but the latter two species differ in having smooth upper surfaces, wider lobes, and oblong ascospores. Morphologically, *N. pseudocomplicata* is similar to *N. rugosa,* which is distinguished by having olivetoric acid in thallus.

Ecology & distribution—The species is corticolous, occurring at 3982–4135 m in Arunachal Pradesh. Previously *N. pseudocomplicata* was known from Japan, Sakhalin Island, and Taiwan (Randlane & al. 1994). This is the first record for India.

Nephromopsis pseudoweberi (Essl.) Divakar, A. Crespo & Lumbsch, Fungal Diversity 84: 113 (2017) FIG. 6A,B

≡ *Tuckermanella pseudoweberi* Essl., Mycotaxon 85: 139 (2003)

THALLUS foliose, corticolous, loosely adnate, 5–8 cm in diam., usually more or less orbicular; lobes 0.5–1.7 mm wide, rounded to elongate, flat to weakly concave; upper surface dark brown to brown or reddish brown, dull to slightly shiny, linear pseudocyphellate; soredia and isidia absent; lower surface brown to dark brown, mostly smooth to weakly
rugose, dull; rhizines present always in the central thallus and sometimes at the margin, sparse, simple, concolorous; medulla white. APOTHECIA ≤4 mm diam., margin crenate to papillate, bearing pseudocyphellae on the crenae or papillae; ascospores hyaline simple, subglobose to ellipsoid, 7–9 × 4–6 µm. PYCNIDIA black, immersed to weakly emergent, mostly laminal or submarginal; pycnoconidia bifusiform 4–6 µm.

CHEMISTRY—Medulla K–, C–, KC–, P–; caperatic acid is present in TLC.

SPECIMENS EXAMINED—**INDIA, ARUNACHAL PRADESH, Tawang district**, Sela Pass, alt. 4135 m, on bark, 17 June 2015, R. Bajpai 15-026511 (LWG). **SIKKIM, South Sikkim district**, Kupup Gnathang (HSP-1), alt. 3703 m, on bark, 23 April 2014, R. Bajpai 14-024922 (LWG); **North Sikkim district**, Ganthang (HSP-2), alt. 3862 m, on bark, 28 April 2014, R. Bajpai 14-024922/B (LWG).

REMARKS—*Nephromopsis pseudoweberi* is morphologically similar to *N. weberi* (Essl.) Divakar & al., which is distinguished by having olivetoric or physodic acids; *N. pseudoweberi* similar in morphology to *N. arizonica* (Essl.) Divakar & al., which differs in having 2-3 lichesterinic acid.

ECOLOGY & DISTRIBUTION—*Nephromopsis pseudoweberi* is common on tree twigs at 3703–4135 m in Arunachal Pradesh and Sikkim. Earlier this species was reported from Mexico (Esslinger 2003). This is the the first record for India.

Nephromopsis rhytidocarpa (Mont. & Bosch) Zahlbr., Annals Cryptog. Exot.1(2): 208 (1928)

≡ *Cetraria rhytidocarpa* Mont. & Bosch in Jungh., Pl. Jungh. 4: 430 (1856)

≡ *Cetreliopsis rhytidocarpa* (Mont. & Bosch.) Randlane & Saag, in Randlane, Thell & Saag, Mem. Natn Sci. Mus, Tokyo 13: 218 (1980)

THALLUS foliose to subfruticose, corticolous, loosely attached, 12 cm across; lobes 10–15 mm wide, irregularly undulate, imbricate; upper surface yellowish grey to grey black blotched along the marginal area; laminal pseudocyphellae with or without fibrils along rim; isidia and soredia absent; lower surface brown to black with pseudocyphellae, rhizines dispersed in groups, black, usually simple, sometimes furcated, ≤1 mm long; medulla white. APOTHECIA marginal,

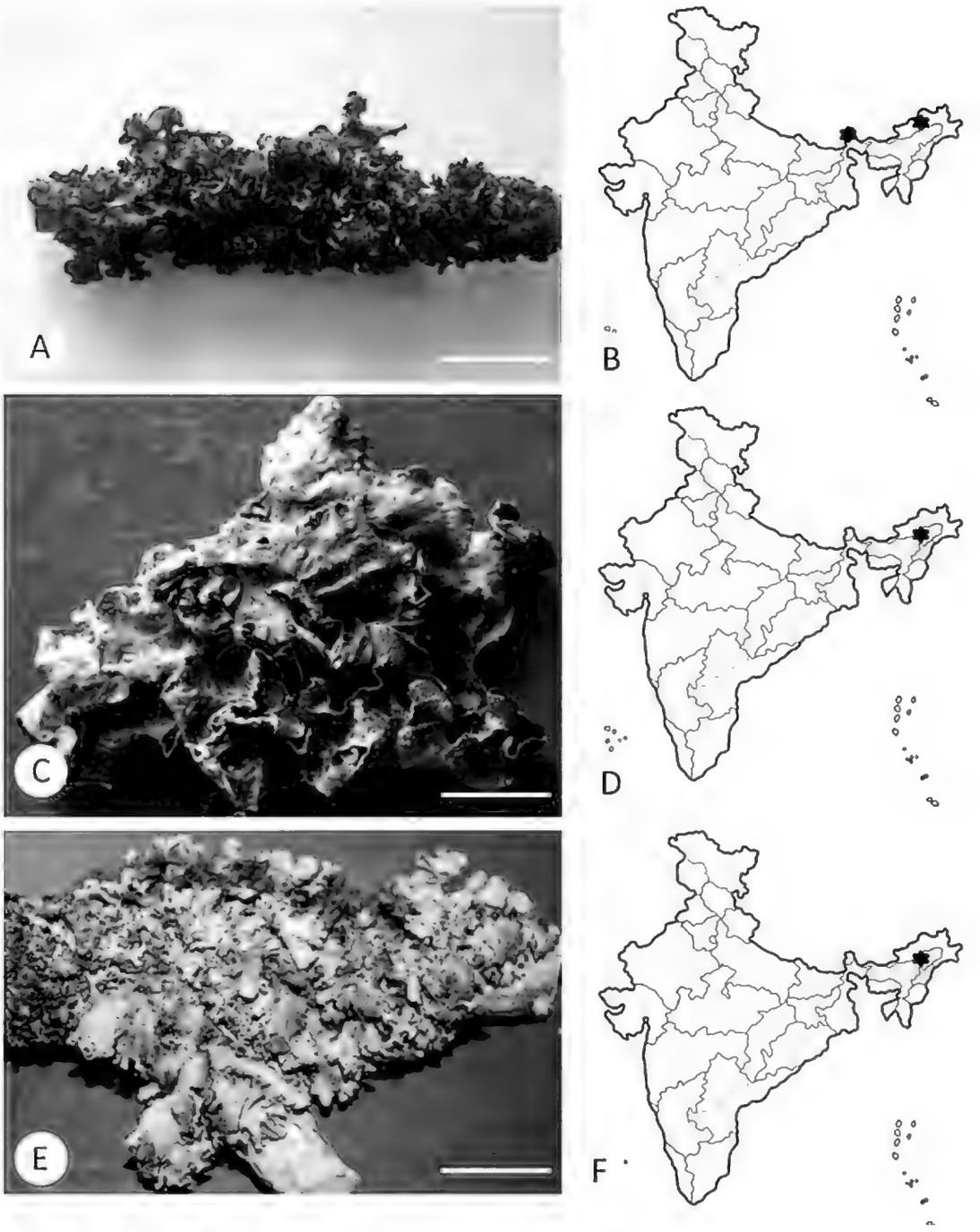


Fig. 6. ***Nephromopsis pseudoweberi*** (LWG 14-024922.) A. habit; B. Indian distribution. ***Nephromopsis rugosa*** (LWG 19-037819). C. habit; D. Indian distribution. ***Nephromopsis yunnanensis*** (LWG 15-026566). E. habit; F. Indian distribution. Scale bars: A, C, E = 1 cm.

rounded, ≤10 mm in diam., peltate to slightly nephromoid; ascospores 5–11 × 4–7 µm. Pycnidia not seen.

Chemistry—Medulla K+ yellow to red, C–, KC–, P+ orange; fumarprotocetraric and protocetraric acids; traces of lichesterinic and protolichesterinic acids present in TLC.

Specimens examined—**INDIA, Andaman Islands**, Middle Andaman Long Island, on bark, 27.3.1961, A. Singh & Party 89408, 89415 (LWG), North East, NEFA; Parila, alt. 3000 m, on bark, 2.4.1957, G. Pauigrohi 6397C (LWG), Kalaktang to Norsing, on dead wood, 15.5.1958, G. Ranigrahi 15707 (LWG-AWAS). **Sikkim**, **East Sikkim**, Rechala surroundings, alt. 2700-2900 m, on bark, G.P. Sinha 1003 B (BSHC); **West Sikkim**, Near Bakhim, alt. 2500-2700 m, on bark, G.P. Sinha 707 (BSHC). **Uttarakhand, Bageshwar district**, enroute to Pindari Glacier from Loharghet to Dhakuri, on bark, 10.5.2007, S. Joshi & Y. Joshi 07-010080 (LWG), Dhakuri, alt. 2580 m, on bark, 23.5.1972, A. Singh 89347, 89340, 89339/B, 89339/A (LWG), 22.5.1972, A. Singh 89326 (LWG), Khati to Dwali, alt. 2210-2734 m, on bark, 12.5.2007, S. Joshi & Y. Joshi 07-010076 (LWG); **Pithoragarh district**, Kalamuni, alt. 2670 m, on bark, 18.6.1973, A. Singh 102679 (LWG), Munsiyari, Nain Singh Top, alt. 2700 m, on bark, 15.9.1996, D.K. Upreti & J. Tandon L104639 (LWG). **West Bengal**, **Darjeeling district**, Sandakhpoo-Phalut, alt. 11000-12000 ft, on bark, 6.6.1960, M.N. Bose 60.138 (LWG), Batasi-Palmajua, alt. 8000 ft, on bark, June 1948, D.D. Awasthi 396 (LWG-AWAS). **Manipur**, on bark, Watt 6949 (LWG).

Remarks—In having pseudocyphellae on both sides, *Nephromopsis rhytidocarpa* closely resembles *N. asahinae* (M. Satô) Räsänen, which differs in having yellowish green (not brownish) pigmentation, a thinner and less coriaceous thallus with wider lobes, lacks a P+ orange-red medulla, and has protocetraric, fumarprotocetraric, and physodalic acids in the thallus.

Ecology & distribution—*Nephromopsis rhytidocarpa* is corticolous and is distributed at 2210–4000 m in Andaman Islands, Manipur, Sikkim, Uttarakhand, and West Bengal's Darjeeling district.

Nephromopsis rugosa Asahina, *J. Jap. Bot.*11(no. 1): 12 (1935) Fig. 6c,d

≡ *Cetraria rugosa* (Asahina) M. Satô, in Nakai & Honda, Nova Flora Japonica 1: 46 (1939)

Thallus foliose, corticolous, loosely attached, 7–20 cm in diameter; lobes rounded ≤3 cm wide; upper surface yellowish or greenish tinge, regularly reticulate; soredia and isidia absent; lower surface light whitish, yellowish to brown, reticulate, rhizines simple, sparse; pseudocyphellae on lower surface in the form of minute flat white spots; medulla white. Apothecia marginal on the lower side of thallus, rounded or reniform, 5–15 mm in diam., disc brown; asci clavate, 35–40 × 7–10 µm; ascospores hyaline, oblong, 7–9 × 3–5 µm. Pycnidia frequent, marginal to laminal, on black emergent projection; pycnoconidia bifusiform, 2–5 × 1–1.5 µm.

Chemistry—Medulla K–, C+ pink, KC+ red, P–; usnic acid in cortex and olivetoric acid are present in TLC.

Specimen examined—**INDIA, Arunachal Pradesh, Tawang District**, Madhwei Lake, Tawang, alt. 3708 m, on bark of *Abies* tree, 14. November 2013, R. Debnath 19-037819 (LWG).

Remarks—*Nephromopsis rugosa* shares a C+, KC+ thallus with *N. stracheyi*, which differs in lacking reticulate thallus and olivetoric acids. *Nephromopsis laii,* which also has oblong ascospores, differs in a slightly rugose thallus and the presence of lichesterinic and protolichesterinic acids.

Ecology & distribution—*Nephromopsis rugosa* is corticolous and occurs at 3708 m in Arunachal Pradesh. Previously this species was known from Russia, Japan, Mongolia (Schubert & Klement 1977). This is the first record for India.

Nephromopsis sikkimensis (Divakar & Upreti) Randlane & Saag, Cryptog. Mycol. 34: 90 (2013)

≡ *Tuckneraria sikkimensis* Divakar & Upreti, Bot. J. Linnean Soc. 150: 249 (2006)

Thallus foliose, corticolous, loosely attached, ≤13 mm wide; lobes 4–8 mm wide, margin ciliate; cilia black to brown, ≤2 mm long; upper surface pale yellow to yellow, smooth, shiny; soredia and isidia absent; lower surface black, pale brown at margins, smooth to slightly rugose; pseudocyphellae present, punctiform near periphery and elliptic towards centre, brown to black rimmed; rhizines present in central part of thallus; medulla white. Apothecia unknown. Pycnidia marginal, emergent and verruciform; pycnoconidia citriform, 3 × 1 µm.

Chemistry—Medulla K–, C–, KC–, P–; usnic acid in cortex; lichesterinic acid present in TLC.

Specimens examined—**INDIA, Sikkim, North Sikkim**, 2 km before Shinghbo Rhododendron Sanctuary, near Yumthang, alt. 3500 m, on bark, 15.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004112, 04-004195 (LWG). **Uttarakhand, Bageshwar district**, Phurkia to Pindari Glacier, near Mirtoli, alt. 3400 m, on bark, 11.6.1970, D.D. Awasthi 7695 (LWG-AWAS).

Remarks—*Nephromopsis sikkimensis* shares the presence of cilia and usnic and lichesterinic acids with *N. ahtii,* which can be separated by its grey to greenish upper surface and bifusiform pycnoconidia measuring 5 × 1.5 µm.

Ecology & distribution—*Nephromopsis sikkimensis* is corticolous, growing on *Rhododendron* bushes in moist and open places at 3400–3500 m. Its distribution is restricted to the states of Sikkim and Uttarakhand.

Nephromopsis stracheyi (C. Bab.) Müll. Arg. Flora 74: 374 (1891)

≡ *Cetraria stracheyi* C. Bab., Hooker's J. Bot. Kew Gard. Misc. 4: 245 (1852)

≡ *Platysma stracheyi* (C. Bab.) Nyl., Syn. Meth. Lich. 1: 305 (1860)

Thallus foliose, corticolous, loosely attached, 15–20 cm across; lobes convoluted, ≤3–4 cm wide, lacking black fibrils along margins; upper surface

greenish grey to yellowish green, smooth to rugose; isidia and soredia lacking; lower surface pale brown, reticulately nervose-rugose; pseudocyphellae sessile or depressed on plain surface or on ridges; rhizines short, sparse, ≤1 mm long; medulla white. Apothecia marginal on lower side, nephromoid, oblong or reniform, 15 × 10 mm in size; ascospores simple, hyaline, 5–9 × 3 µm. Pycnidia not seen.

Chemistry—Medulla K–, C+ red, KC+ red, P–; usnic acid in cortex; anziaic, lichesterinic, and protolichesterinic acids present in the medulla in TLC.

Specimens examined—**INDIA, Arunachal Pradesh, West Kameng district**, Bomdila to Rahung, alt. 8200ft., on bark, 15.5.1958, R.S. Rao 7358 (LWG). **Sikkim, West Sikkim district**, Dzongri, alt. 4000 m, on bark, 23.5.1960, M.N. Bose B (LWG-AWAS). **Uttarakhand, Bageshwar district**, Dhakuri ridge, alt. 3000 m, on bark, 8.6.1970, D.D. Awasthi 7591 (LWG-AWAS), 22.5.1972, A. Singh 89312/A (LWG), from Dhakuri to Khati, alt. 2638 m, on bark, 11.5.2007, S. Joshi & Y. Joshi 01-010069 (LWG), Dwali to Kafni, alt. 3500 m, on bark, 25.5.1972, A. Singh 89351 (LWG), Dhakuri ridge, alt. 3000 m, on bark, 8.6.1970, D.D. Awasthi 7591 (LWG-AWAS), 19.5.1950, D.D. Awasthi & A.M. Awasthi 642/B (LWG-AWAS), Dhakuri Pass, alt. 3000 m, on bark, 4.6.1982, P.C. Pande 82-54363 (LWG), enroute to Pindari Glacier, Dwali to Kafni, alt. 2800 m, on bark, 24.5.1997, D.K. Upreti, S. Chattejee & J. Tandon L69071 (LWG), Sunderdhunga Glacier, between Jatoli and Dhuniyadon, alt. 3700 m, bark, 14.9.1995 (LWG); **Pithoragarh district,** Kalamuni, alt. 2670 m, on bark, 18.6.1973, A. Singh 102678 (LWG), Dharchula Sobhla, near village Vatan, alt. 2700 m, on bark, 26.9.1990, D.K. Upreti & G. Hariharan 202018 (LWG), Munsiyari, alt. 2250 m, on bark, 18.6.1973, A. Singh 102684 (LWG), Sirdung, Narain Swami Ashram, alt. 2400 m, on bark, 29.10.1983, D.K. Upreti L18425, L18410 (LWG), 2.11.2009, D.K. Upreti & G.K. Mishra 09-012196 (LWG), 29.10.1983, D.K. Upreti L18425 (LWG), Dharchula Shobla, near village Vatam, alt. 2700 m, on bark, 26.9.1990, D.K. Upreti & G. Hariharan 202018 (LWG), Kalamuni, alt. 2670 m, on bark, 18.6.1973, A. Singh 102678 (LWG); **Uttarkashi district**, Tehri Garhwal to Jamunotri, alt. 11500 ft, on bark, 22.6.1951, D.D. Awasthi 910 (LWG-AWAS). **West Bengal, Darjeeling district**, Tiger Hill, alt. 2800 m, on bark, 17.4.1960, M. N. Bose 6232, 6233 (LWG-AWAS), 5.3.1967, D.D. Awasthi & M.R. Agrawal, 67.49, 67.49 (LWG-AWAS), 6.10.1957, D.D. Awasthi 3877 (LWG), on way from Sandakhpoo to Phalut, alt. 4000 m, on bark, 16.6.1967, D.D. Awasthi & M.R. Agrawal 67.442, 67.509 (LWG-AWAS), near Pahnjua, alt. 3500 m, on bark, June 1948, D.D. Awasthi 176 (LWG-AWAS), Batasi to Paluajua, alt. 3600 m, on bark, June 1948, D.D. Awasthi 177 (LWG-AWAS), above Lachung Shingringtang area, alt. 2900 m, on bark, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004265 (LWG), Tiger hill, alt..7500 ft, on bark, 17.4.1960, M.N. Bose 6232, 6233 (LWG-AWAS), 6.6.1960, M.N. Bose 60.139 (LWG-AWAS), Tiger hill, north face, alt. 8500 ft, on bark, 5.5.1967, D.D. Awasthi & M.R. Agrawal 67.49 (LWG-AWAS).

Remarks—*Nephromopsis stracheyi* is similar to *N. rugosa*, which differs in having olivetoric acid in the medulla and smaller pseudocyphellae.

Ecology & distribution—*Nephromopsis stracheyi* is found growing on trees in open places at 2500–4500 m; it is widely distributed in Arunachal Pradesh, Sikkim, Uttarakhand, and West Bengal's Darjeeling district.

Nephromopsis togashii (Asahina) A. Thell & Kärnefelt,
Mycological Progress 4(4): 311 (2005)
≡ *Cetraria togashii* Asahina, J. Jap. Bot. 28: 136 (1953)
≡ *Tuckneraria togashii* (Asahina) Randlane & A. Thell, J. Hattori Bot. Lab. 78: 238 (1995)

Thallus fruticose, corticolous, ≤10 cm across; lobes 2–5 mm wide; upper surface yellow, fibrils absent at margin; lower surface pale brown to yellowish white; isidia coralloid branched, mainly marginal but occasionally laminal, soredia absent; pseudocyphellae plane and white, on lower surface; rhizines 1–2 mm long, dark brown to blackish; medulla white. Apothecia absent. Pycnidia frequent, spherical or subspherical, black coloured; pycnoconidia bifusiform (dumb-bell shaped), 3.7–4.5 × 1–1.5 µm in size.

Chemistry—Medulla K–, C–, KC+ yellow, P–; usnic acid in cortex; protolichesterinic acid present in TLC.

Specimens examined—**INDIA, Sikkim, North Sikkim**, 4 km from Lachung, alt. 3100 m, on *Cedrus deodara* tree trunk, 15.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004145, 04-004053 (LWG).

Remarks—*Nephromopsis togashii* shares an isidiate appearance with *Usnocetraria kurokawae* (Shibuichi & Yoshida) Lai & Wei, which can be distinguished in having different secondary metabolites containing fumarprotocetraric acid.

Ecology & distribution—This species is corticolous, growing on *Cedrus deodara* at 3100 m in Sikkim.

Nephromopsis weii X.Q. Gao & L.H. Chen, Mycotaxon 77: 492 (2001) Fig. 7
≡ *Tuckermannopsis weii* (X.Q. Gao & L.H. Chen) Randlane & Saag, Mycotaxon 87: 479 (2003)
≡ *Usnocetraria weii* (X.Q. Gao & L.H. Chen) M.J. Lai & J.C. Wei, J. Natnl Taiwan Mus.60 (1): 57 (2007)

Thallus foliose, corticolous, loosely attached, ≤5 cm in diam.; lobes ≤2–5 mm wide; upper surface olive brown to brown, smooth, shiny; soredia and isidia absent; lower surface pale brown to dark brown and slightly rugose, rhizines simple, sparse, laminal or marginal; pseudocyphellae on both surfaces; medulla white. Apothecia not seen. Pycnidia on tip of projections, black; pycnoconidia bifusiform, 3.5–4.5 × 1–1.5 µm.

Chemistry—Medulla K–, C–, KC–, P–; lichesterinic, protolichesterinic, and caperatic acids are present in TLC.

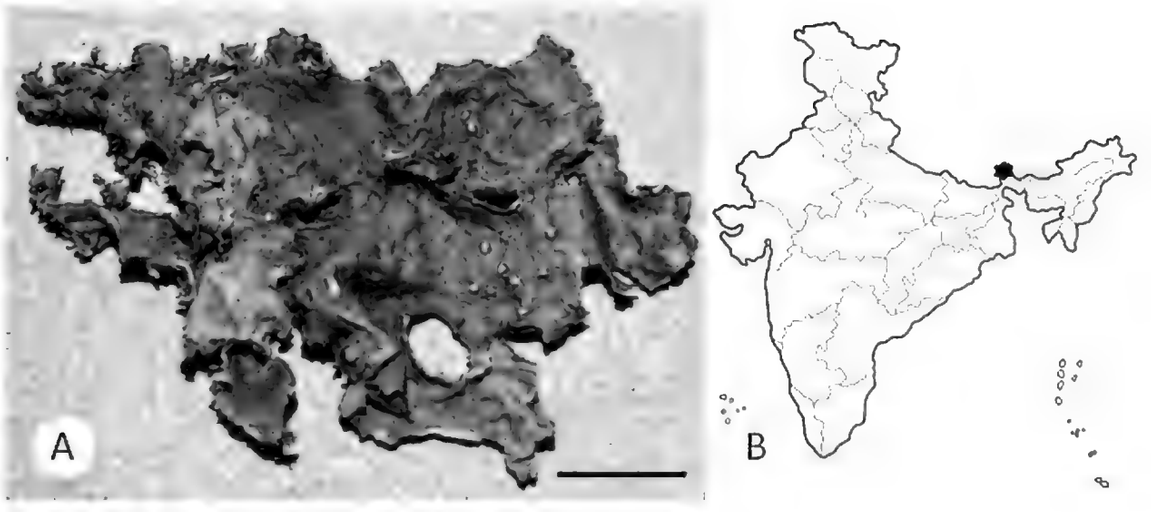


FIG. 7. ***Nephromopsis weii*** (LWG 04-004133).
A. habit; B. Indian distribution. Scale bar = 1 cm.

SPECIMEN EXAMINED—**INDIA, SIKKIM, North Sikkim**, Shingba Rhododendron Sanctuary, near Yumthang, alt. 3500 m, on bark, 15 August 2004, D.K. Upreti, S. Chetterjee & P.K. Divakar 04-004133 (LWG).

REMARKS—*Nephromopsis weii* shares having pseudocyphellae on both sides of the thallus with *N. rhytidocarpa,* which can be distinguished by having a P+ red medulla (instead of P– thallus); *N. weii* is also morphologically similar to *N. thailandica* (Elix & M.J. Lai) Divakar & al., which differs in its K+ yellow-brown and P+ orange-red medulla.

ECOLOGY & DISTRIBUTION—*Nephromopsis weii* grows on bark at ca. 3500 m in Sikkim Himalaya. This species was described from China (Chen & Gao 2001), and this is the first lichen record for India.

Nephromopsis yunnanensis (Nyl.) Randlane & Saag,
Mycotaxon 44(2): 488 (1992) FIG. 6E,F
≡ *Platysma yunnanensis* Nyl., Lich. Nov. Zeland. (Paris): 150 (1888)

THALLUS foliose, corticolous, loosely attached, ≤20 cm in diameter; lobes rounded ≤5–15 mm wide; upper surface yellow to brownish; soredia and isidia absent; lower surfaces whitish to pale brown and extremely rugose, rhizines simple, sparse, laminal or marginal; pseudocyphellae on lower surface on ridges and plug-like outgrowth; medulla white. APOTHECIA not seen. PYCNIDIA frequent, marginal to laminal, on black, emergent projection; pycnoconidia bifusiform, 3–5 × 1–1.5 µm.

CHEMISTRY—Medulla K–, C–, KC–, P–; usnic acid, lichesterinic, and protolichesterinic acids are present in TLC.

Specimen examined—**INDIA, Arunachal Pradesh, Tawang district**, Nagula, near Nagula lake, alt. 4137 m, on bark, 15 June 2015, R. Bajpai 15-026566 (LWG).

Remarks—*Nephromopsis yunnanensis* is morphologically and chemically similar to *N. ahtii,* which differs in possessing marginal cilia and emergent pycnidia; *N. yunnanensis* is also similar to *N. laii* in having pseudocyphellae on ridges; however, *N. laii* differs in having abundant apothecia.

Ecology & distribution—*Nephromopsis yunnanensis* grows on bark, at 4137 m in the Eastern Himalayan state of Sikkim. Earlier this species was reported from China and Xizang (Randlane & Saag 1998, 2001). This is a new lichen record for India.

Platismatia W.L. Culb. & C.F. Culb., Contr. U.S. Nat. Herb. 34: 524 (1968)

Thallus foliose, dorsiventral, heteromerous, rosette forming or wide spreading, lobate; lobes 3-25 mm wide, margin often ascending, wavy, sometimes crisped; upper and lower surface with a well-developed paraplectenchymatous cortex; upper surface grey to olivaceous green, with punctiform pseudocyphellae; isidia and sometimes soredia present; lower surface pale or black with few, scattered rhizines; photobiont green alga; medulla white. Apothecia marginal to submarginal; disc brown, often perforate; asci 8-spored; ascospores colourless, simple, ellipsoid or subglobose, 3.5–10 × 3–5 µm. Pycnidia marginal, immersed, or absent; pycnoconidia cylindrical, not swollen at apices.

Out of 11 species of *Platismatia* known worldwide (Randlane & al. 2013), a single species is reported from India.

Platismatia erosa W.L. Culb. & C.F. Culb.,
Contr. U. S. Natl. Herb. 34: 526 (1968)

Thallus foliose, terricolous, loosely attached, medium ≤12 cm across; lobes 5–20 mm wide, broadly rounded; upper surface light tan or ashy-grey, tinged with brown at the margins of the lobes, broadly reticulately ridged and veined; pseudocyphellate, pseudocyphellae with minute pores and often bearing isidial scars resembling pseudocyphellae; isidia usually infrequent, short, simple and usually confined to the ridges or thallus cracks but becoming coralloid and well developed at the margin of lobes; soredia absent; lower surface punctiform, jet black, the marginal zone light brown or tan; rhizines few, black, simple or fasciculate, confined to older parts; medulla white. Apothecia marginal to submarginal ≤7 mm broad; asci 8- spored, IKI+ dark blue; ascospores ellipsoid, 3–4 ×5–8 µm. Pycnidia not seen.

Chemistry—Thallus K+ yellow, C–, P–, KC–; atranorin and caperatic acids present in TLC.

Specimens examined—**INDIA, Sikkim, East Sikkim district**, near Karponang, alt. 2500 m, on soil, May 1947, D.D. Awasthi 354 (LWG), alt. 8500ft., on soil, May 1947, D.D. Awasthi 354 (LWG-AWAS), near Yumthang, alt. 3800 m, on soil, 15.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004161 (LWG); **North Sikkim district**, Near Yumthang, alt. 3800 m, on soil, 15.8.2004, D.K. Upreti, S. Chatterjee & P.K. Divakar 04-004161 (LWG), near Karponang, Kupup, north border side, alt. 4100–4200 m, on soil, G.P. Sinha 1511 (BSHC), Memencho lake surroundings, alt. 3200–3500 m, on soil, G.P. Sinha 1472 (BSHC), Shingba Rhododendron Sanctuary, alt. 3350 m, on soil, G.P. Sinha 1068 (BSHC), The Lajakthang way, alt. 4600–3400 m, on soil, G.P. Sinha 1711 (BSHC), Near Bakhim, alt. 3900–3500 m, on soil, G.P. Sinha 716 (BSHC), on way to between Dzongri-Thangsing foot track, alt. 3900–3500 m, on soil, G.P. Sinha 816 (BSHC).

Remarks—*Platismatia erosa* closely resembles *P. interrupta* W.L. Culb. & C.F. Culb., in having pseudocyphellae on the upper surface and isidia along the margins or on ridges of lobes, but *P. interrupta* differs in having large and conspicuous pseudocyphellae and a non-punctate lower surface.

Ecology & distribution—*Platismatia erosa* is terricolous, occurring at 2500–4600 m and only in the state of Sikkim in eastern Himalaya.

Acknowledgements

We thank the director of the CSIR-National Botanical Research Institute, Lucknow for providing laboratory facilities under OLP101. One author, GKM, would like to thank the Department of Science & Technology, New Delhi for award of N-PDF (PDF/2017/000356) and Dr. Tiina Randlane (University of Tartu, Estonia) for her valuable suggestions. We thank Director of the Botanical Survey of India (Sikkim Himalaya Regional Centre, Gangtok) for lending specimens from herbarium BSHC. We thank Drs. Edit Farkas (Institute of Ecology and Botany, Centre for Ecological Research, Vácrátót, Hungary) and Beeyoung Gun Lee (Baekdudaegan National Arboretum, Bonghwa, South Korea) for reviewing the manuscript and providing valuable suggestions for improvement. Manuscript number of CSIR-NBRI is MS/2021/08/01.

Literature cited

Acharius E. 1803. Methodus lichenum. Stockholm.

Awasthi DD. 1982. Lichen genus *Cetraria* in India and Nepal. Bulletin of the Botanical Survey of India 24: 1–27.

Awasthi DD. 2000. Lichenology in Indian subcontinent. A supplement to A Handbook of Lichens. Bishen Singh Mahendrapal Singh, Dehradun.

Awasthi DD. 2007. A compendium of the macrolichens from India, Nepal and Sri Lanka. Bishen Singh Mahendrapal Singh, Dehradun.

Babington C. 1852. Lichenes Himalayenses: being an enumeration of the lichens collected in the Himalayan Mountains by Captain R. Strachey of the Bengal Engineers and J.E. Winterbottom, Esqr. F. L. S. during the years 1847–48. Hooker's Journal of Botany and Kew Garden Miscellany 4: 243–252.

Brodo IM, Sharnoff SD, Sharnoff S. 2001. Lichens of North America. Yale University Press, New Haven & London. 795 p.

Chen L, Gao X. 2001. Two new species of *Nephromopsis* (*Parmeliaceae, Ascomycota*). Mycotaxon 77: 491–496.

Divakar PK, Upreti DK. 2003. New species and new records of *Parmotrema* (*Parmeliaceae*) from India. Lichenologist 35(1): 21–26. https://doi-org/10.1006/lich.2002.0426

Divakar PK, Upreti DK. 2006. Notes on some new records and new species of cetrarioid lichens from India. Botanical Journal of the Linnean Society 150: 249–251. https://doi.org/10.1111/j.1095-8339.2006.00455.x

Divakar PK, Crespo A, Kraichak E, Leavitt SD, Singh G, Schmitt I, Lumbsch T. 2017. Using a temporal phylogenetic method to harmonize family and genus level classification in the largest clade of lichen-forming fungi. Fungal Diversity. 84: 101–117. https://doi-org:10.1007/s13225-017-0379-z

Esslinger T. 2003. *Tuckermanella,* a new cetrarioid genus in western North America. Mycotaxon, 85: 135–141.

Gyelnik V. 1933. Lichenes varii novi critique. Acta pro Fauna et Flora Universalis Botanici (Bucuresti), series 2, 1(5–6): 3–10.

Jagadeesh Ram TAM, Sinha GP. 2010. Some additions to the lichen flora of India. Phytotaxonomy 10: 118–121.

Kärnefelt I. 1979. The brown fruticose species of *Cetraria*. Opera Botanica 46. 150 p.

Kärnefelt I, Thell A. 1996. A new classification for the *Dactylina/Dufourea* complex. Nova Hedwigia 61: 595–605.

Kärnefelt I, Mattsson JE, Thell A. 1992. Evolution and phylogeny of cetrarioid lichens. Plant Systematics and Evolution 183: 113–160. https://doi.org/10.1007/bf00937739

Kärnefelt I, Mattsson JE, Thell A. 1993. The lichen genera *Arctocetraria, Cetraria* and *Cetrariella* (*Parmeliaceae*) and their presumed evolutionary affinities. Bryologist 96: 394-404. https://doi.org/10.2307/3243869

Kärnefelt I, Emanuelsson K, Thell A. 1998. Anatomy and systematic of usneoid genera in the *Parmeliaceae*. Nova Hedwigia 67: 71–92. https://doi-org/10.1127/nova.hedwigia/67/1998/71

Krog H. 1982. Evolutionary trends in foliose and fruticose lichens of *Parmeliaceae*. Journal of Hattori Botanical Laboratory 52: 303–311.

Mishra GK, Upreti DK. 2015a. Lichens flora of Kumaun Himalaya. Lambert Academic Publishing, Saarbrücken. 620 p.

Mishra GK, Upreti DK. 2015b. Altitudinal distribution of cetrarioid lichens in Govind Wildlife Sanctuary, Garhwal Himalaya, Uttarakhand. Geophytology 45(1): 9–19.

Orange AP, James W, White FJ. 2001. Microchemical methods for the identification of lichens. British Lichen Society, U.K.

Randlane T, Saag A. 1998. Synopsis of the genus *Nephromopsis* (fam. *Parmeliaceae*, lichenized *Ascomycota*). Cryptogamie, Bryologie-Lichénologie 19(2–3): 175–191.

Randlane T, Saag A. 2001. Cetrarioid lichens containing usnic acid from the Tibetan Area. Mycotaxon 80: 389–425.

Randlane T, Thell A, Saag A, Kärnefelt I. 1994. The genus *Tuckneraria* Randl. & Thell – a new segregation in the family *Parmeliaceae*. Acta Botanica Fennica 150: 143–151.

Randlane T, Thell A, Saag A. 1995. New data about the genera *Cetrariopsis, Cetreliopsis* and *Nephromopsis* (*Parmeliaceae*, lichenized *Ascomycotina)*. Cryptogamie, Bryologie–Lichénologie 16: 35–60.

Randlane T, Saag A, Thell A, Ahti T. 2013. Third world list of cetrarioid lichens — in a new database for documentation of nomenclatural data-lessons learned. Taxon 62(3): 591–603.

Rassadina K A. 1950. Tsetraria *Cetraria* CCCP. Trad. Botanicheskogo Instituta Akademii Nauk. S.S.S.R., ser. 2, Sporovye Rastenija 5: 171–304. (In Russian).

Schubert R, Klement O. 1977. Beitrag zur Flechtenflora der Mongolischen Volksrepublik. Feddes Repertorium 82(3–4): 187–262.

Singh KP, Sinha GP (2010). Indian lichen: an Annotated checklist. Botanical Survey of India.

Sinha GP, Elix JA. 2003. A new species of *Hypogymnia* and a new record in the lichen family *Parmeliaceae* (Ascomycota) from Sikkim. Mycotaxon 87: 81–84.

Sinha GP, Singh KP. 2005. Macrolichens of Sikkim. Botanical Survey of India, Kolkata.

Thell A. 1995. A new position of the *Cetraria commixta* group in *Melanelia* (*Ascomycotina, Parmeliaceae*). Nova Hedwigia 60(3–4): 407–422.

Thell A. 1996. Anatomy and taxonomy of cetrarioid lichens. Summary of doctoral dissertation. Department of Systematic Botany, Lund University.

Thell A, Crespo A, Divakar PK, Kärnefelt I, Leavitt SD, Lumbsch HT, Seaward MRD, 2012. A review of the lichen family *Parmeliaceae* – history, phylogeny and current taxonomy. Nordic Journal of Botany 30 (6): 641–664. https://doi.org:10.1111/j.1756-1051.2012.00008.x

Wang RF, Wei XL, Wei JC. 2015. The lichen genus *Allocetraria* (*Parmeliaceae)* in China. Mycotaxon 130: 577–591. https://doi.org/10.5248/130.577

Wei J. 1991. An enumeration of lichens in China. Beijing, International Academic Publisher. 278 p.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 335–344

https://doi.org/10.5248/137.335

First record of *Lactocollybia variicystis* from Asia

Aiman Izhar*, Muhammad Usman, Hira Bashir, Shazia Ashraf, Abdul Rehman Niazi, Maria Latif & Abdul Nasir Khalid

Fungal Biology and Systematics Research Laboratory, Institute of Botany, University of the Punjab, Quaid-e-Azam Campus-54590, Lahore, Pakistan

* Correspondence to: *aimanizhar25@gmail.com*

Abstract—During surveys of macrofungi in Pakistan, eight specimens belonging to the genus *Lactocollybia* were collected from the plains of Punjab and foothills of Murree. Morphological studies and molecular characterization refer all collections to a single species, *Lactocollybia variicystis*, previously restricted to Africa and Europe; this is the first report from Asia. Except for geography, no significant differences were found among African, European, and Pakistani collections.

Key words—*Agaricales*, gloeocystidia, *Gymnopus*, macrocystidia, taxonomy

Introduction

Lactocollybia Singer is represented by 20 species (www. Indexfungorum.com, accessed October 2020) that are mostly tropical (some subtropical) with a few species reported from South and North America (Singer 1986, Senthilarasu & Kumaresan 2016). *Lactocollybia* accommodates species that are collybioid or (less frequently) pleurotoid and characterized by mostly pure white carpophores, slightly to non-hygrophanous pilei, stipes that are mostly distinct (but may be reduced to absent) and lack annuli, latex that is mostly present, and with a white to creamy spore print. Anatomically, these saprophytic fungi produce basidiospores that are thin-walled and inamyloid and tissues that frequently possess gloeovessels or gloeocystidia throughout. Most species are lignicolous, but others fruit on soil, humus, and bark of

living trees. Morphologically, *Lactocollybia* resembles *Macrocystidia* in its abundant gloeocystidia, frequent cystidia, and inamyloid basidiospores, but the genus is separated by its white spore print and acyanophilic basidiospore walls (Singer 1986). Among white-spored mushrooms, *Gymnopus* (Pers.) Roussel, similar in form to *Lactocollybia*, differs in its irregularly arranged coralloid elements, present on the edge of the pileipellis (Antonín & al. 2013).

Lactocollybia is divided into five small sections based on the basidiome structure (collybioid, mycenoid, omphalioid, or pleurotoid), pigmentation, subhymenial structure; the presence or absence of latex, clamp connections, and gloeocystidia; and habit on living tree stumps, bark, or fallen fruit (Singer 1970, 1986; Hosen & al. 2016; Senthilarasu & Kumaresan 2016). *Lactocollybia variicystis* is referred to *L.* sect. *Albae* Singer based on its basidiomata lacking a veil and latex production, the presence of clamp connections and numerous gloeocystidia, and a lignicolous habit. Only a single species has previously been reported from Pakistan: *Lactocollybia angiospermarum* Singer [= *L. epia* (Berk. & Broome) Pegler] (from districts Lahore, Narowal, and Sargodha on bark of *Ziziphus jujuba* Mill. and *Dalbergia sissoo* DC.; Ahmad 1980).

Molecular phylogenetic analyses for the genus have not yet been completed, and only a few sequences of the nrITS (nuclear ribosomal internal transcribed spacer) region and partial sequences of the nuclear large subunit (nrLSU) are available at NCBI. Here we generated eight nrITS sequences from basidiomata of *Lactocollybia variicystis* collected from Pakistan during 2016–18. The species was originally described from South Africa, (Reid & Eicker 1998) and later reported from Spain (Menorca, with a Mediterranean climate) and equatorial west Africa (São Tomé, with a tropical maritime climate) (Salom & Siquier 2014; Desjardin & Perry 2017; Chou & al. 2020). This report of its occurrence (from a subtropical dry climate on loamy soil of Pakistan) represents the fourth worldwide and the first from Asia.

Material & methods

Morphology

Fresh samples were collected in the districts of Gujrat, Hafizabad, Islamabad, and Sheikhupura (all in Punjab, Pakistan) and photographed in natural light. Basidiomata were dried using a fan heater. Macroscopic characters were described from fresh material and field photographs, and microscopic features were obtained by reviving hand-sections of dried basidiomata for examination under a light microscope. Mountants used were 5% KOH, Melzer's reagent (for basidiospore amyloidy) and 1% Congo red (for staining gill tissues). Sections were studied at magnifications ≤1000×. Color terms follow Munsell (1975). A minimum 20 basidiospores, basidia,

cheilocystidia, pleurocystidia, pileus and stipe elements from each collection were measured using ScopeImage 9.0(X5). Abbreviations include avl = average length, avw = average width, Q = basidiospore length/width ratio, and avQ = mean Q of all basidiospores. All collections were deposited in the Herbarium, Institute of Botany, University of the Punjab, Lahore, Pakistan (LAH).

Molecular studies

Approximately 2 mg of fungal tissue was taken from dried specimens to extract DNA following a modified CTAB protocol (Bruns 1995). The universal fungal primer pairs ITS1F (Gardes & Bruns 1993) and ITS4 (White & al. 1990) were used to amplify the ITS region following the PCR procedure of 1 min denaturation at 94 °C; then 35 cycles for 30 sec, 1 minute at 50 °C, and 1.5 min at 72 °C; ending with a final elongation for 1 min at 72 °C. The ITS amplicons were sequenced by TsingKe (Beijing, China).

Sequences were compared using the BLAST tool available on the NCBI database. For phylogenetic reconstruction, BLAST searches were executed to find sequences showing maximum identity, and those referred by Hosen & al. (2016) were retrieved from GenBank. The multiple sequences were aligned using MUSCLE (Edgar 2004), then manually adjusted in BioEdit (Hall 1999). A phylogenetic tree using Maximum

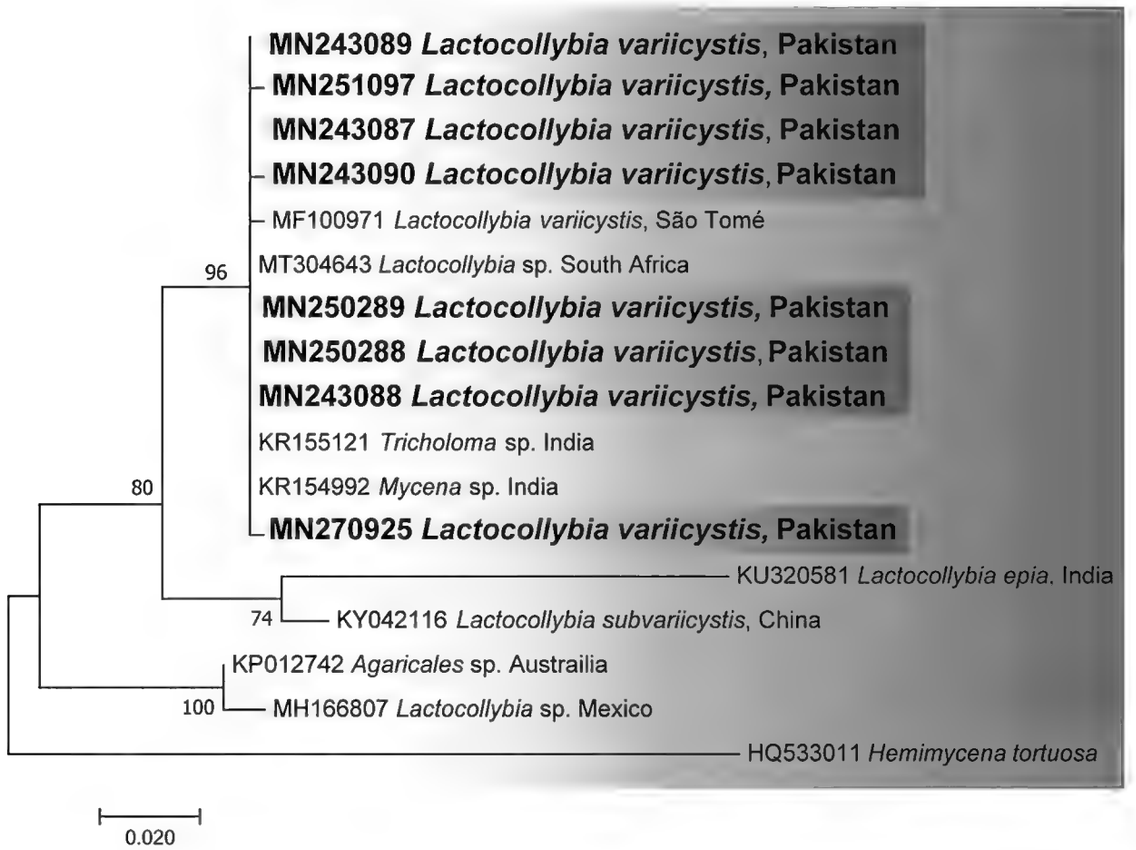


Fig. 1. Phylogram of *Lactocollybia variicystis* obtained by Maximum Likelihood method based on ITS sequences. Bootstrap values ≥70% are given above or below the branches. Species collected from Pakistan are highlighted in bold.

Likelihood criteria and the Neighbor-Joining method was constructed in MEGA7 using Jukes-Cantor model under 1000 bootstrap replicates (Jukes & Cantor 1969, Kumar & al. 2016). Clades with a BS value >50% were regarded as highly supported (Hillis & Bull 1993). This aligned sequence data matrix was exported to Adobe illustrator CS v.3 for editing.

Molecular phylogenetic results

The nrDNA ITS sequences from all collected *L. variicystis* basidiocarps measured 623–638 bp. In BLAST, the Pakistani *L. variicystis* sequences showed 99% similarity with a specimen from India labelled as *Mycena* sp. (KR154992) and 98% similarity with *Lactocollybia variicystis* (MF100971) from São Tomé. Sequences included in the final analysis represented the outgroup *Hemimycena tortuosa* (HQ533011), different *Lactocollybia* species, and a few closely related BLAST sequences. The resulting phylogeny nested all Pakistani *L. variicystis* sequences in the same clade as previously reported *Lactocollybia* species (Fig. 1).

Taxonomy

Lactocollybia variicystis D.A. Reid & Eicker,
Mycotaxon 66: 159. 1998. Figs 2, 3

Basidiomata small, dry, ≤2.7–3.0 cm. Pileus 1.4–2.9 cm, avw = 1.9 cm diameter, reniform when immature, broadly convex to plano-convex at maturity, slightly depressed at disc, margins plicate-sulcate striate, surface smooth, white (N10), pale yellow when bruised. Lamellae light pink (5YR8/8), adnate, horizontal, close to subdistant, crisped, edges even, lamellulae in 1–2 tiers, wavy. Stipe 1.0–1.5 × 0.5–0.8 cm, central to eccentric, almost equal, rarely tapered towards base, hollow; dry, minutely pruinose, white to pale yellow when old. Odor cabbage-like. Taste not recorded.

Basidiospores (6.4–)7.4–9.4(–9.8) × (4.8–)5.2–5.8(–6.2) µm, avl × avw = 7.9 × 5.4 µm, Q = 1.4–1.6, avQ = 1.5, broadly ellipsoid to ellipsoid, some amygdaliform, thin-walled, smooth, apiculate, multi-guttulate, inamyloid, hyaline in KOH. Basidia 22.5–29.5 × 6.5–9.5 µm, avl × avw = 23.8 × 7.8 µm, thin-walled, hyaline in KOH, narrowly clavate, 2–4-spored, guttulate. Cheilocystidia 47.5–76.5 × 6.5–15.5 µm. avl × avw = 55.6 × 11.7 µm, frequent, thin-walled, hyaline in KOH, narrowly cylindrical to fusoid, ventricose, sometimes lageniform, capitate, inamyloid. Gloeocystidia 53–105 × 9–23 µm, clavate, some ventricose with obtuse apex, omnipresent throughout gills. Pleurocystidia 49–79 × 6.5–16 µm, avl × avw = 56 × 10.5 µm, frequent, thin-walled, hyaline in KOH, narrowly cylindrical, versiform,

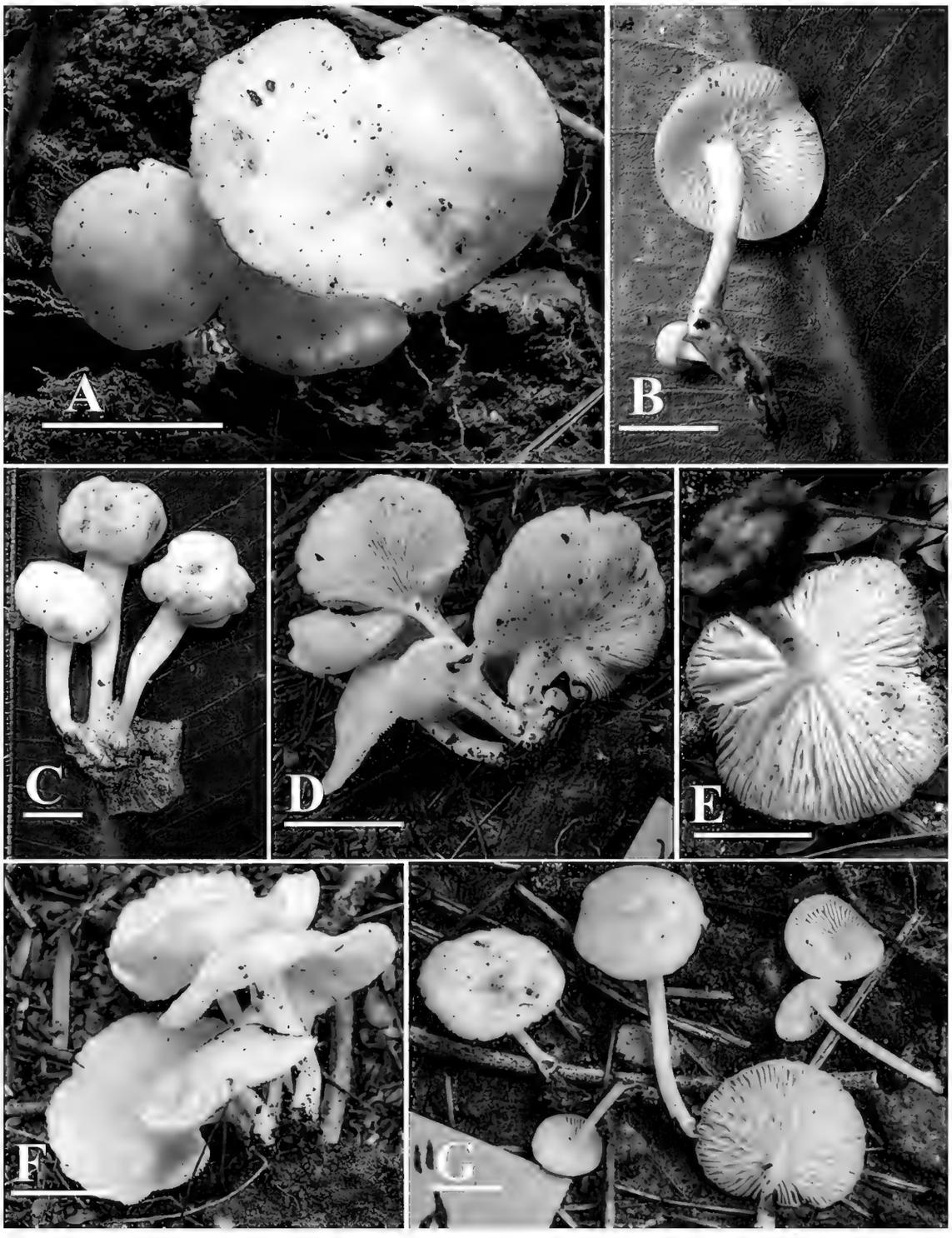


Fig. 2. *Lactocollybia variicystis*: basidiomata: A, B = LAH35712: C = LAH36360: D, F = LAH35348: E = LAH35347: G = LAH35346. Scale bars = 1 cm.

cylindrically capitate, inamyloid. Pileipellis with cutis, hyphae (2.5–5 µm), radially arranged with elements of gloeosystem interspersed, later appearing as fusoid intercalary swellings, hyaline in KOH, inamyloid; gloeocystidia

110–132 × 5–14 µm, narrowly clavate, versiform; loosely interwoven. Stipitipellis a cutis; hyphae 2.5–8.2 µm broad, avw = 5.1 µm, irregularly arranged, hyaline in KOH; gloeocystidia 88–120 × 9.7–16.9 µm, with yellowish golden refractive contents, variable intercalary swellings present. Clamp connections frequent.

Habitat & distribution—Gregariously growing on bark of *Psidium guajava* L. and *Vachellia nilotica* (L.) P.J.H. Hurter & Mabb. Previously reported from Africa and Europe, and now for the first time from Asia.

Specimens examined—**PAKISTAN. Punjab: Sheikhupura district**, 31.7111°N 73.9878°E, elevation 236 m a.s.l., gregarious on tree bark of *Psidium guajava,* 16 July 2017, Aiman Izhar SKP12_2 (LAH 35712; GenBank: MN250288); 1 August 2018, Aiman Izhar SKP12_1 (LAH 36360; GenBank: MN250289). **Gujrat district**, Pabbi Forest Park, 32.8315°N 73.8360°E, elevation 286 m a.s.l., gregarious on the bark of *Vachellia nilotica*, 11 August 2016, Muhammad Usman & Abdul Nasir Khalid MU14 (LAH 35346; GenBank: MN243087); 25 August 2016 MU15 (LAH 35347; GenBank MN243088); 1 August 2017, MU26 (LAH 35348; GenBank: MN243089); 5 August 2018, MU55 (LAH 35349; GenBank: MN243090). **Islamabad district**, 33.7167°N 72.9167°E, elevation 1604 m a.s.l., on bark, 17 July 2017, Shazia Ashraf MH9 (LAH 36396; GenBank: MN251097). **Hafizabad district**, 32.3333°N 73.7667°E, elevation 207 m a.s.l., on bark, 30 July 2017, Muhammad Ali HZ-54 (LAH35808; GenBank: MN270925).

Discussion

Our phylogenetic analysis grouped all nrITS sequences generated from Pakistani *Lactocollybia* collections (MN250288, MN250289, MN243087, MN243088, MN243089, MN243090, MN251097, MN270925) with *L. variicystis* (MF100971) from São Tomé, *Tricholoma* sp. (KR155121), and *Mycena* sp. (KR154992) from India.

Until now few *Lactocollybia* species have been molecularly analyzed. Our study includes eight Pakistani collections from four sampling sites. Two collections (SKP12_2 and SKP 12_1) were on the bark of *Psidium guajava* from Sheikhupura, a subtropical to dry, industrial area of Punjab subject to extreme climate variations and heavy rainfall during the monsoon season from mid-June to August. The average rainfall is 630 mm and the area has mixed loamy-textured soil (Shaheen & al. 2019). The district flora is dominated by *Senegalia modesta* (Wall.) P.J.H. Hurter, *V. nilotica*, *Prosopis cineraria* (L.) Druce, and *Tamarix aphylla* (L.) H. Karst. (Rahim & al. 1975, Izhar & al. 2019).

Four collections (MU-14, MU-15, MU-26, and MU-55) were made from Pabbi Forest Park (Gujrat district, a portion of Himalayan foothills) spread

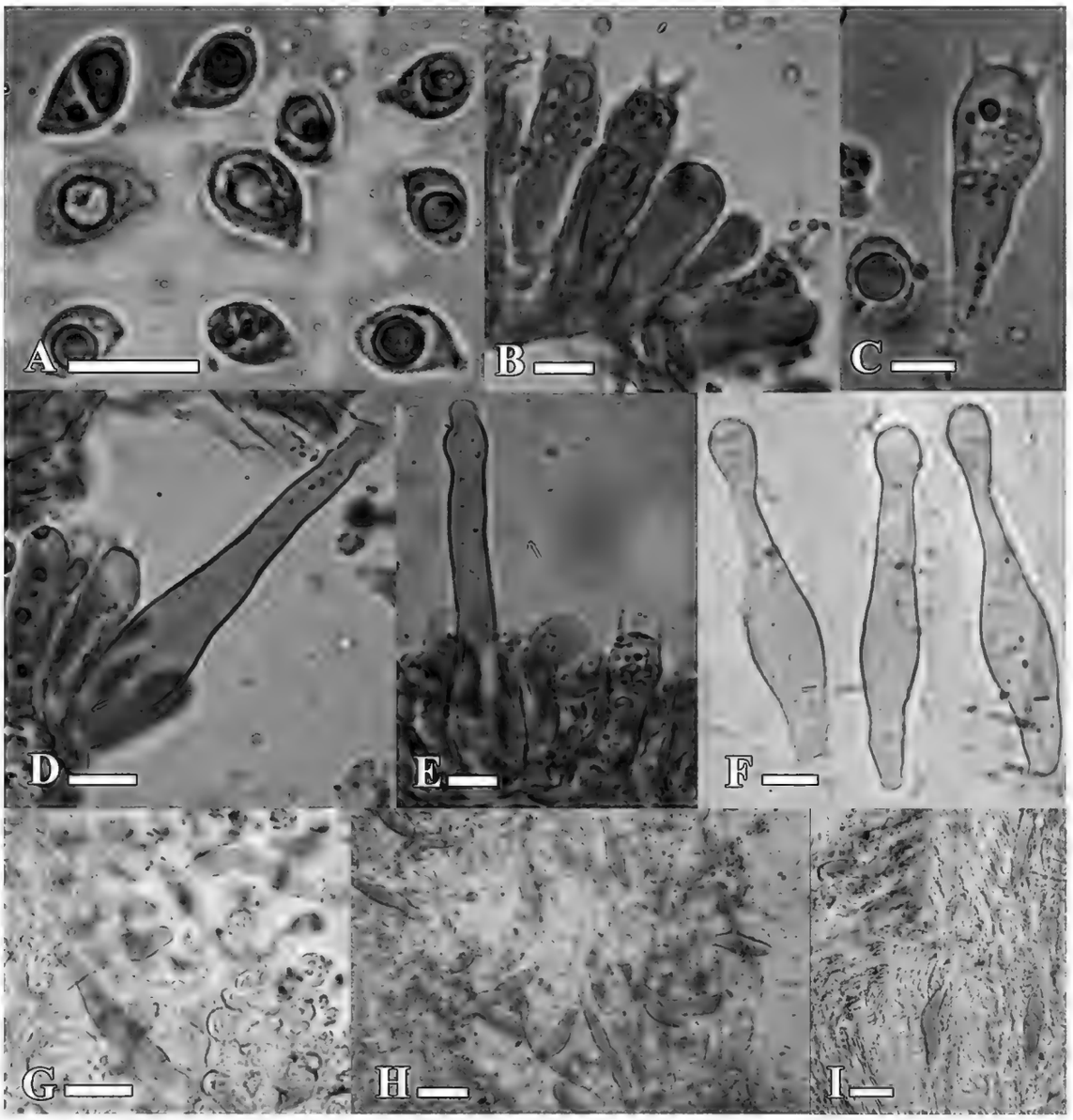


Fig. 3. *Lactocollybia variicystis* (LAH 35712, LAH 36360). A. basidiospores; B, C. basidia; D, E. cheilocystidia; F. pleurocystidia; G. gloeocystidia in lamellae; H. gloeocystidia in pileus; I: gloeo-elements in stipe. Scale bars: A = 10 µm; B, C = 20 µm; D–F = 10 µm; G–I = 30 µm.

almost over 160 km^2 dominated by *S. modesta*, *Grewia tenax* (Forssk.) Fiori, and *Prosopis juliflora* (Sw.) DC and with an annual rainfall of 774 mm per year (Usman & Khalid 2018). The basidiomata occurred gregariously on bark at the base of *Vachellia nilotica*. One collection (HZ-54) was from district Hafizabad with a semi-arid climate and an annual rainfall of 50–70 mm (Umair & al. 2017). The last collection (MH9) is from Margalla hills, (Islamabad), having a humid subtropical climate and a dominant vegetation including *Senegalia modesta* and *V. nilotica*.

The Pakistani *L. variicystis* collections share a remarkable similarity with the African type material from a *Salix* stump in a humid subtropical climate (Reid & Eicker (1998). The South African specimen contrasted with our collection by its slightly narrower (≤1.8 cm) pileus, longer and thinner stipe (maximum 3.2 × 0.2 cm), shorter basidiospores (max length = 8 µm), smaller cheilocystidia (avl × avw = 17–40 × 5–11 µm), and pleurocystidia resembling gloeocystidia.

The Pakistani *L. variicystis* has a pileus slightly depressed at the center, in contrast to the broadly umbonate pilei of the São Tomé specimens of *L. variicystis* collected from decaying banana and cacao plants in a hot, humid, tropical maritime climate (Desjardin & Perry 2017). Other features shared by the Pakistani and São Tomé collections are golden gloeosystem elements with central swellings and narrow edges scattered throughout the pileus and stipe. Our collections differ in their wider (avw = 1.9 cm) pilei, which are significantly smaller (0.6 cm) in European collections. Basidiospores from Pakistani collections are relatively broad (4.8–6.2 µm) compared to those in European collections (3.5–5.2 µm; Salom & Siquier 2014). Phylogenetically, there were four differences between the Pakistani and São Tomé DNA sequences (at the 64, 197, 225, and 249 bp positions) but, except for the two or three minor differences mentioned above, no significant morphological differences have been observed, supporting identification of the Pakistani specimens as *L. variicystis.*

The similar *Lactocollybia epia* (KU320581) and *L. variicystis* are both characterized by a convex to plane pileus with a depressed center and the same basidiospore spore size (6–9 × 4–6 µm) in the descriptions given by Corner (1994) and Yang (2000). However, subsequent reports clearly separate *L. epia* by its larger basidiomata with a 1–5 cm broad pileus and stipe measuring 2–8 × 0.2–0.5 cm, much more elongated and thinner basidiospores (7.5–11 × 4.2–5 µm), and cylindrical to clavate cheilocystidia (Pegler 1977, 1986; Cortez & Sulzbacher 2009).

Our phylogenetic analysis places *L. variicystis* closer to *L. subvariicystis* Hosen & T.H. Li (first described from China) in the same clade. Both species share a subtropical habitat, small white basidiomata, gloeosystemic elements in pileus and stipe, and frequent clamp connections. Contrasting features include in *L. subvariicystis* the presence of adnate to sinuate lamellae, long narrow basidiospores (8–10.5 × 4.5–5.3 µm), scarcely plicate margins, and association with *Acacia confusa* Merr. (Hosen & al. 2016).

Acknowledgements

The authors are grateful to Higher Education Commission, Pakistan, for financial assistance under National Research Program for Universities (project no. 20-3383/NRPU/R&D/HEC/14/184). We are sincerely obliged to Dr. Arun Kumar Dutta, (Department of Botany, West Bengal State University, Barasat, India) and Dr. Aamna Ishaq (Department of Biological Sciences, University of Veterinary & Animal Sciences (UVAS), Ravi Campus, Pakistan) for their peer review and valuable comments on this manuscript for Mycotaxon. We also obliged to Dr. Munazza Kiran (Fungal Biology and Systematics Research Laboratory, Institute of Botany, University of the Punjab, Lahore, Pakistan) for initially reviewing and commenting on this research article. Special thanks are due to Dr. Amy Y. Rossman (Dept. of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon, USA) for linguistic revision of the manuscript.

Literature cited

Ahmad S. 1980. A contribution to the *Agaricales* of Pakistan. Bulletin of Mycology 1(1): 35–90.

Antonín V, Sedlák P, Tomšovský M. 2013. Taxonomy and phylogeny of European *Gymnopus* subsection *Levipedes* (*Basidiomycota*, *Omphalotaceae*). Persoonia 31: 179 –187. https://doi.org/10.3767/003158513X674043

Chou SC, Lyra AA, Gomes JL, Rodriguez DA, Martins MA, Resende NC & al. 2020. Downscaling projections of climate change in São Tomé and Príncipe Islands, Africa. Climate Dynamics 54(9): 4021–4042. https://doi.org/10.1007/s00382-020-05212-7

Corner EJH. 1994. Agarics in Malesia. Beihefte zur Nova Hedwigia 109. 271 p.

Cortez VG, Sulzbacher MA. 2009. *Lactocollybia epia (Basidiomycota):* nova ocorrência para o Rio Grande do Sul. Revista Brasileira de Biociências 7(1): 9–13.

Desjardin DE, Perry BA. 2017. The gymnopoid fungi *(Basidiomycota, Agaricales)* from the Republic of São Tomé and Príncipe, West Africa. Mycosphere 8: 1317–1391. https://doi.org/10.5943/mycosphere/8/9/5

Edgar RC. 2004. MUSCLE: multiple sequence alignment with high accuracy and high throughput. Nucleic Acids Research 32(5): 1792–1797. https://doi.org/10.1093/nar/gkh340

Gardes M, Bruns TD. 1993. ITS primers with enhanced specificity for *Basidiomycetes* – application to the identification of mycorrhizae and rusts. Molecular Ecology 2: 113–118. https://doi.org/10.1111/j.1365-294X.1993.tb00005.x

Hall TA. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT/7. Nucleic Acids Symposium Series 41: 95–98. https://doi.org/10.4172/2167-0412.1000264

Hillis DM, Bull JJ. 1993. An empirical test of bootstrapping as a method for assessing confidence in phylogenetic analysis. Systematic Biology 42: 182–192. https://doi.org/10.1093/sysbio/42.2.182

Hosen MI, Li TH, Chen XN, Deng WQ. 2016. *Lactocollybia subvariicystis*, a new species of little known genus *Lactocollybia* from subtropical south China. Mycosphere 7(6): 794–800. https://doi.org/10.5943/mycosphere/7/6/10

Izhar A, Bashir H, Khalid AN. 2019. A new species of *Conocybe (Bolbitaceae* [sic]*)* from Punjab, Pakistan. Phytotaxa 402(5): 251–258. https://doi.org/10.11646/phytotaxa.402.5.4

Jukes TH, Kantor CR. 1969. Evolution of protein molecules. 21–123, in: HN Munro (ed.). Mammalian Protein Metabolism, vol. 2. New York: Academic Press.

Kumar S, Stecher G, Tamura K. 2016. MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets. Molecular Biology & Evolution 33: 1870–1874. https://doi.org/10.1093/molbev/msw054

Munsell A. 1975. Munsell soil color charts. Macbeth Division of Kollmorgen Corporation. Baltimore, Maryland.

Pegler DN. 1977. A preliminary agaric flora of East Africa. Kew Bulletin, Additional Series 6: 1– 615.

Reid DA, Eicker A. 1998. South African fungi 6. The genus *Lactocollybia (Basidiomycota)* in South Africa. Mycotaxon 66: 153–163.

Salom JC, Siquier JL. 2014. *Lactocollybia variicystis* DA Reid & Eicker, una rara especie alóctona encontrada en Menorca (Illes Balears, España). Zizak 10: 59–67.

Senthilarasu G, Kumaresan V. 2016. Diversity of agaric mycota of Western Ghats of Karnataka, India. Cream 6(2): 75–101. https://doi.org/10.5943/cream/6/2/3

Shaheen A, Iqbal J, Hussain S. 2019. Adaptive geospatial modeling of soil contamination by selected heavy metals in the industrial area of Sheikhupura, Pakistan. International Journal of Environmental Science and Technology 16(8): 4447–4464. https://doi.org/10.1007/s13762-018-1968-4

Singer R. 1970. *Omphalinae* (*Clitocybeae–Tricholomataceae, Basidiomycetes*). Flora Neotropica 3. 84 p.

Singer R. 1986. The *Agaricales* in modern taxonomy. 4th ed. Koeltz Scientific Books. Koenigstein.

Umair M, Altaf M, Abbasi AM. 2017. An ethnobotanical survey of indigenous medicinal plants in Hafizabad district, Punjab, Pakistan. PloS ONE 12(6): e0177912. https://doi.org/10.1371/journal.pone.0177912

Usman M, Khalid AN. 2018. *Leucoagaricus pabbiensis* sp. nov. from Punjab, Pakistan. Mycotaxon 133(2): 354–363. https://doi.org/10.5248/133.355

White TJ, Bruns T, Lee S, Taylor J. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. 315–322, in: MA Innis & al. (eds). PCR protocols: a guide to methods and applications. Academic Press, San Diego CA. https://doi.org/10.1016/B978-0-12-372180-8.50042-1

Yang ZL. 2000. Notes on five common but little known higher basidiomycetes from tropical Yunnan, China. Mycotaxon 74(1): 45–56.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 345–351

https://doi.org/10.5248/137.345

The first record of the coprophilous *Coemansia erecta* in South America

Mateus Oliveira da Cruz &
André Luiz Cabral Monteiro de Azevedo Santiago*

Departamento de Micologia, Universidade Federal de Pernambuco;
Av. da Engenharia, s/n, 50740-600, Recife, Pernambuco, Brazil

* Correspondence to: *andrelcabral@msn.com*

Abstract — During a survey of the coprophilous zygosporic fungal diversity in the State of Pernambuco, Brazil, *Coemansia erecta* was recovered from dung of *Cavia porcellus* (guinea pig). This is the first record of this species in South America. Images and a description of the Brazilian specimen are presented and discussed. An identification key for species of *Coemansia* from South America is provided.

Key words—*Kickxellaceae, Kickxellomycota,* taxonomy, zygosporic fungi

Introduction

Kickxellaceae Linder, one of the six families that belong to *Kickxellomycota* Tedersoo & al. (Tedersoo & al. 2018, Wijayawardene & al. 2022), was erected by Linder (1943) to accommodate species that form septate sporangiophores with lenticular cavities containing plugs lacking polar protuberances (Benny & al. 2001). These sporangiophores bear septate or aseptate sporocladia with pseudophialides and merosporangia (Linder 1943, Chuang & al. 2017). *Kickxellaceae* comprises *Coemansia* Tiegh. & G. Le Monn., *Dipsacomyces* R.K. Benj., *Kickxella* Coem., *Linderina* Raper & Fennell, *Martensella* Coem., *Martensiomyces* J.A. Mey., *Mycoemilia* Kurihara & al., *Myconymphaea* Kurihara & al., *Pinnaticoemansia* Kurihara & Degawa, *Spirodactylon* R.K. Benj., and *Spiromyces* R.K. Benj.

Coemansia, like other genera of *Kickxellaceae*, was accommodated in the hyphomycetes because of the reduced number of spores per merosporangium, in addition to the development of these merosporangia by a process of apical budding, similar to the conidial formation in some imperfect fungi. However, Linder (1943) observed morphological similarities of asexual reproductive structures of *Coemansia* spp. with those of *Syncephalastrum* J. Schröt. and *Syncephalis* Tiegh. & G. Le Monn., as well as the production of zygospores by *Coemansia* spp.; since then *Coemansia* has been treated as a zygosporic fungus, and the family *Kickxellaceae* was accepted (Linder 1943, Benjamin 1959).

Coemansia spp. are characterized by forming sporangiophores that are septate, erect, simple or presenting regular or irregular branches that acrogenously and laterally form sporocladia disposed by continued growth of the fertile axis arising pleurogenously (Linder 1943, Kurihara & al. 2008). Sporocladia vary among species in terms of their size and number of septa which delimit cells that support pseudophialides on their lower surfaces. Each pseudophialide produces a single sporangiolum that releases a single sporangiospore in a droplet of fluid when it is mature (Benjamin 1958, 1959). In some *Coemansia* species sporocladia are borne around a straight sporogenous region and in other species around a twisted sporogenous region (Chuang & Ho 2011).

Species of *Coemansia* have been isolated from dung, soil, humus, plant roots, and some specific coleopterous larvae (Linder 1943, Kwaśna & al. 1999). These species are most frequently isolated from rodent dung (Benny 2008), but they have also been isolated from the dung of rabbits and bats (Benjamin 1958), frogs (Ho & Hsu 2005), and horses, ducks, pigs, and water buffalo (Linder 1943).

Twenty-five species of *Coemansia* have been described (Wijayawardene & al. 2022), including *C. erecta*, first described by Bainier (1906) from France. A few *Coemansia* species have been recorded in South America: *C. aciculifera* Linder and *C. pectinata* (Coem.) Bainier have been reported in Argentina (GBIF 2021), while *C. aciculifera* (Mota 2011) and *C. brasiliensis* Linder (Linder 1943) have been cited in Brazil (Fig. 1A). Here we present the first record of *C. erecta* in South America, from northeastern Brazil. An illustration of this Brazilian isolate is presented, and aspects of its morphology are discussed.

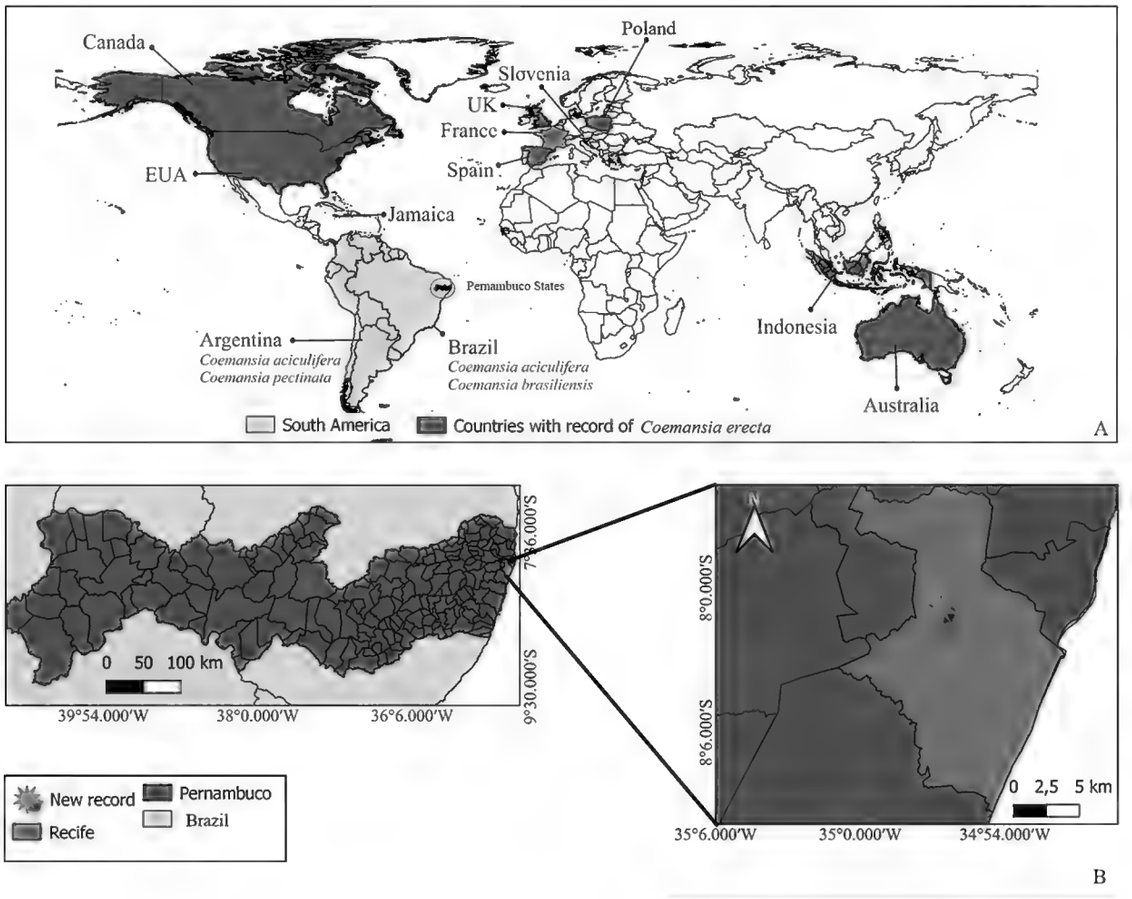


Fig. 1 *Coemansia erecta*: maps of distribution and new record: A. Worldwide distribution of *C. erecta* and current insight of *Coemansia* in South America; B. Location of *C. erecta* in State of Pernambuco, Brazil.

Materials & methods

Excrement of *Cavia porcellus* L. (guinea pig) was collected in the Parque Estadual de Dois Irmãos (8.0150°S 34.9445°W), an Ecological Reserve located in the city of Recife, state of Pernambuco, Brazil (Fig. 1B). The samples were collected with a spatula previously sterilized in 70% alcohol, placed in plastic bags, and taken to the laboratory where they were incubated in moist chambers (Petri dishes containing 2 filter paper sheets moistened with sterile distilled water) at room temperature (± 28 °C) for 7 days (Benny 2008), in alternate periods of light and dark.

On the third day of observation, *Coemansia erecta* was observed directly on the substrate under a Leica EZ4 stereomicroscope, placed on microscope slides with 2% KOH or lactophenol blue, and observed under a Leica DM500 light microscope. Identification was based on microstructural characters following Linder (1943), Boedijn (1958), and Chuang & al. (2017). Since *C. erecta* could not be successfully grown on corn meal, MEYE, PDA, or PYED (Benny 2008) media, a permanent slide prepared directly from the moist chambers using 50% glycerol containing a small amount of Amann's cotton blue was deposited in the Herbarium, Universidade Federal de Pernambuco, Recife, Pernambuco, Brazil (URM).

Taxonomy

Coemansia erecta Bainier, Bull. Soc. Mycol. France 22: 220 (1906) Fig. 2

Sporangiophores hyaline, erect, simple, distantly septate, 450–985 × 12–22 µm, thin-walled, bifurcate or trifurcate; fertile portion of sporangiophores long, straight, producing sporocladia sympodially. Sporocladial stipe 1-celled, thin-walled, arising at an acute angle from the axis, 4–5 × 2–3 µm. Sporocladia hyaline, with 4–6 septa, excluding the stalks, smooth-walled, 15–22 × 2.5–7 µm; terminal cell hyaline, sterile, 1.5–2.5 × 1–2.5 µm, slightly recurved, coenocytic, with a rounded apex; the distance between sporocladia being 8–12 µm. Pseudophialides hyaline, thin-walled, ovoid, formed on the lower sporocladial surfaces, two arising from each sporocladial cell, 2–3 × 1–1.5 µm. Sporangiola hyaline, thin-walled, monosporic, subcylindrical with rounded apex, 10–12 × 3–4 µm. Sporangiospores subcylindrical, tapering towards the slender truncate base with rounded apex, 8–10 × 2–3 µm (L/W = 3.6).

Specimen examined—**BRAZIL. Pernambuco, Recife**, 8.0150°S 34.9445°W, dung of *Cavia porcellus* (guinea pig), 11.IV.2020, M.O. Cruz 007PEDI1 (URM 94473).

Ecology & Distribution—Dung or soil in Australia, Canada, France, Indonesia, Jamaica, Poland, Slovenia, Spain, United Kingdom, and the United States. This is the first record of *C. erecta* in South America (Fig.1).

Comments—*Coemansia erecta* is mainly distinguished from other species by forming concomitantly bifurcated or trifurcated sporangiophores that do not branch dichotomously and by its subcylindrical sporangiospores showing a truncate base with a rounded apex. *Coemansia guatemalensis* Linder, which is morphologically quite similar to *C. erecta* (see Chuang & al. 2017), is distinguished by occasionally forming bifurcate (never trifurcate) sporangiophores and by its distinctly fusoid sporangiospores with L/W = 6.8, larger than the *C. erecta* sporangiospores (L/W = 3.9). The morphology of the Brazilian specimen was quite similar to those of Bainier (1906), except that the Bainier specimen produced shorter sporangiophores (≤33.6 µm long). Linder (1943) described some structures as larger than those of our specimen: sporangiophores 2–4 mm × 7.2–14 µm, sporocladial stipe 3.5–7.2 µm long, and sporocladia 20–36 × 5.5–6.5 µm. The *C. erecta* specimen described here is morphologically similar to those described by Boedijn (1958), who cited some longer structures: pseudophialides 3–5 × 1.5–2 µm, stalks 4–8 × 3–4 µm, and sporocladia 26–37 × 4–6 µm. Boedijn (1958) also reported 5–9 septa on each sporocladium, while we observed

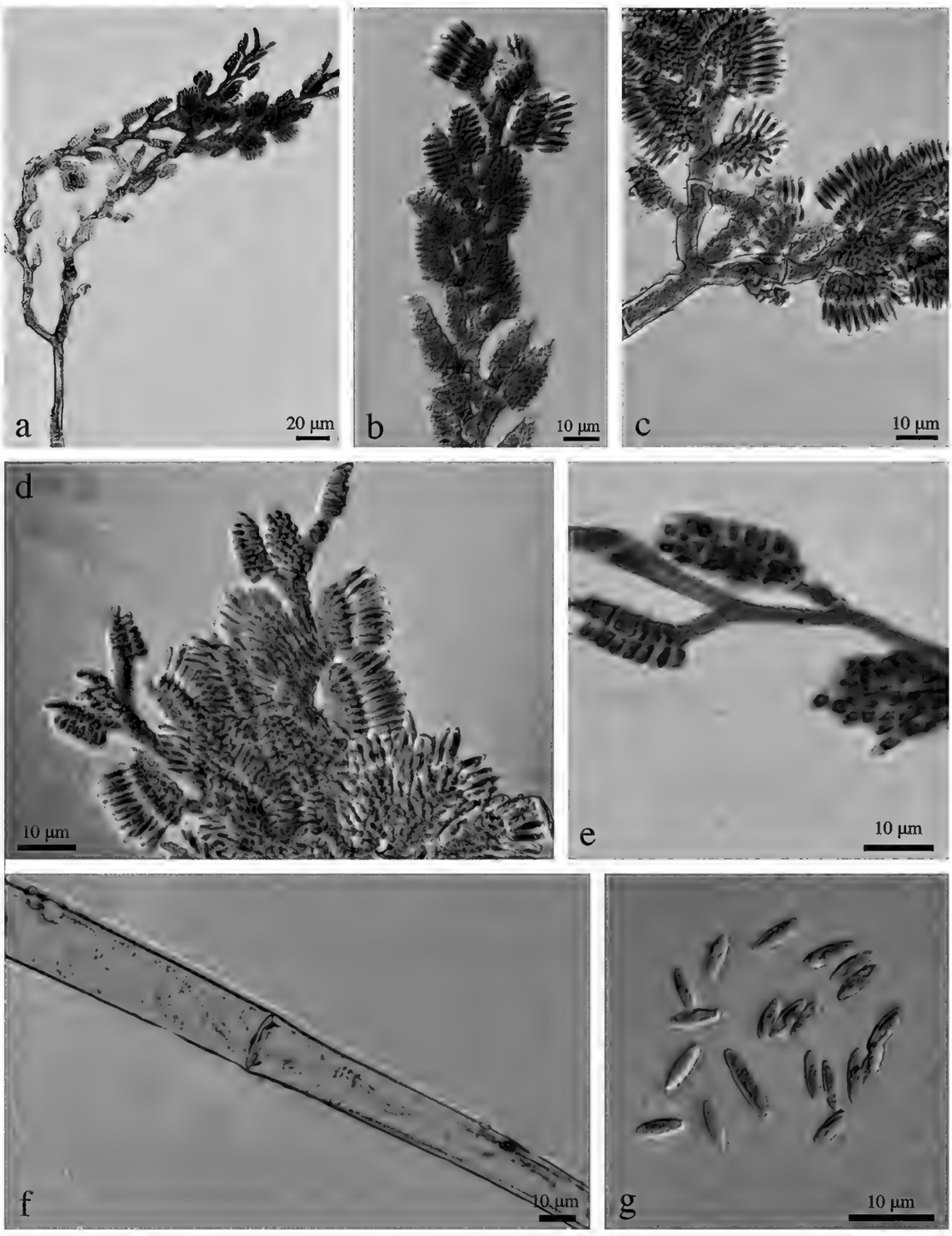


FIG. 2 *Coemansia erecta* (URM 94473): a. Fertile region of a bifurcated sporangiophore; b, d. Apical portion of sporangiophore; c. Fertile region of sporangiophore with trifurcation; e. Sporocladial stipes arising at acute angles from the axis; f. Septum with a lenticular cavity; g. Sporangiospores.

4–6 septa. It should be noted that Linder (1943) pointed out that *C. erecta* is a morphologically variable species.

Key for species of *Coemansia* from South America

1. Fertile region of the sporangiophore bifurcate or trifurcate 2
1. Fertile region of the sporangiophore simple or occasionally furcate 3
2. Sporocladia with fan-like appearance, ≤12-septate ..... *C. brasiliensis*
2. Sporocladia without fan-like appearance, ≤8-septate ..... *C. erecta*
3. Pseudophialides ellipsoidal, sporangiospores acicular ..... *C. aciculifera*
3. Pseudophialides cylindrical, sporangiospores fusiform ..... *C. pectinata*

Acknowledgments

The authors are thankful to Dr. Paul Kirk (Royal Botanic Gardens KEW, UK) and Dr. Hsiao-Man Ho (National Taipei University of Education (retired), Taiwan) for article review and to the National Council for Scientific and Technological Development (CNPq) for providing a scholarship to the first author and a research grant to the second author.

Literature cited

Bainier MG. 1906. Mycothèque de l'École de Pharmacie. VIII, VIII. Bulletin de la Société Mycologique de France 22: 216–223.

Benjamin RK. 1958. Sexuality in the *Kickxellaceae*. Aliso 4: 149–169.

Benjamin RK. 1959. The merosporangiferous *Mucorales*. Aliso 4:321– 433.

Benny GL. 2008. The methods used by Dr. R.K. Benjamin, and other mycologists to isolate *Zygomycetes*. Aliso 26(1): 37–61.

Benny GL, Humber RA, Morton JB. 2001. *Zygomycota: Zygomycetes*. 113–146, in: DJ McLaughlin & al. (eds). The Mycota, Systematics and evolution, Part A. Berlin, Springer-Verlag.

Boedijn KB. 1958. Notes on the *Mucorales* of Indonesia. Sydowia 12: 321–362.

Chuang SC, Ho HM. 2011. The merosporangiferous fungi from Taiwan (VIII): Two new records of *Coemansia* (*Kickxellales, Kickxellomycotina*). Taiwania 56(4): 295–300. https://doi.org/10.6165/tai.2011.56(4).295

Chuang SC, Ho HM, Reynolds N, Smith ME, Benny GL, Chien CY, Tsai JL. 2017. Preliminary phylogeny of *Coemansia* (*Kickxellales*) with descriptions of four new species from Taiwan. Mycologia 109(5): 815–831. https://doi.org/10.1080/00275514.2017.1401892

GBIF. 2021. [continuously updated]. GBIF Home Page. https://www.gbif.org [accessed January 2021].

Ho HM, Hsu CH. 2005. The merosporangiferous fungi from Taiwan (V): two new records of *Coemansia* (*Kickxellaceae, Kickxellales, Zygomycetes*). Taiwania 50: 22–28. https://doi.org/10.6165/tai.2005.50(1).22

Kurihara Y, Sukarno N, Ilyas M, Yuniarti E, Mangunwardoyo W, Park JY, Saraswati R, Widyastuti Y, Ando K. 2008. Indonesian *Kickxellales*: two species of *Coemansia* and *Linderina*. Mycoscience 49: 250–257. https://doi.org/10.1007/S10267-008-0414-8

Kwaśna H, Bateman GL, Dawson WAJM. 1999. *Coemansia* species from the rhizospheres of wheat and barley in the United Kingdom. Mycological Research 103: 896–900. https://doi.org/10.1017/S0953756298008181

Linder DH. 1943. The genera *Kickxella, Martensella* and *Coemansia*. Farlowia 1: 49–77.

Mota MMS. 2011. Aspectos gerais e morfológicos de *Coemansia aciculifera*. Estudos em Doenças de Plantas – IFGoiano. câmpus Urutuí. Viewed online on 20 February 2021: https://fitopatologia1.blogspot.com/2011/12/aspectos-gerais-e-morfologicos-de_19.html

Tedersoo L, Sánchez-Ramírez S, Kõljalg U, Bahram M, Döring M, Schigel D, May T & al. 2018. High-level classification of the fungi and a tool for evolutionary ecological analysis. Fungal Diversity 90(1): 135–159. https://doi.org/10.1007/s13225-018-0401-0

Wijayawardene NN, Hyde KD, Dai DQ, Sánchez-García M, Goto BT & al. 2022. Outline of Fungi and fungus-like taxa – 2021. Mycosphere 13(1): 53–453. https://doi.org./10.5943/mycosphere/13/1/2

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 353–358

https://doi.org/10.5248/137.353

Anthracoidea kenaica— a new record from Russia

Teodor T. Denchev[1,2] & Cvetomir M. Denchev[1,2*]

[1] *Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 2 Gagarin St., 1113 Sofia, Bulgaria*

[2] *IUCN SSC Rusts and Smuts Specialist Group*

* Correspondence to: *cmdenchev@yahoo.co.uk*

Abstract—A rare smut fungus, *Anthracoidea kenaica* on *Carex micropoda,* is reported for the first time from Russia and Asia, based on a specimen from Karaginsky Island (Kamchatka Territory). This species has been previously recorded only from three localities in the Pribilof Islands in the Bering Sea, the Kenai Peninsula (Alaska), and British Columbia. A description, illustrations, and a distribution map are provided. A list of the known *Anthracoidea* species in the Russian Far East is also given.

Key words—amphi-Beringian species, *Anthracoideaceae,* Pauciflora Clade of *Carex* subgen. *Euthyceras, Ustilaginales*

Introduction

Anthracoidea Bref. is the largest genus of smut fungi on host plants in the *Cyperaceae,* comprising 112 species (Denchev & al. 2020, 2021). It is a cosmopolitan genus, but much more species-rich and widely distributed in the northern hemisphere. The smut fungi in this genus possess sori that form globose to broadly ellipsoidal or ovoid, black, hard bodies around aborted nuts of cyperaceous plants. In *Carex* L., the sori are scattered in female spikes or in female flowers of mixed spikes, depending on the *Carex* species. The species of *Anthracoidea* on *Carex* are host-specific smut fungi restricted to sedges belonging to the same or closely related sections (Kukkonen 1963, Vánky 1979, Denchev & al. 2021).

A specimen of *Carex micropoda* C.A. Mey. infected with *Anthracoidea* from the Russian Far East (Karaginsky Island) was found during a visit to the herbarium at the Royal Botanic Gardens, Kew (K) in May 2010. Only one *Anthracoidea* species, *A. kenaica,* is known on *Carex micropoda.* This smut fungus is a rare species, recorded from only three localities: Saint Paul Island (Pribilof Islands in the Bering Sea), Kenai Peninsula (Alaska), and British Columbia (Savile 1952, as '*Cintractia carpophila* var. *kenaica*'; Zambettakis 1978, as '*Anthracoidea heterospora* var. *kenaica*'; Piątek 2013). The type specimen is from the Kenai Peninsula. A morphological examination of the specimen on *Carex micropoda* from the Russian Far East demonstrated its identity with *Anthracoidea kenaica.*

Thirty-five species of *Anthracoidea* are currently known from the Russian Far East: *A. arenaria* (Syd.) Nannf., *A. arnellii* Denchev & al., *A. aspera* (Liro) Kukkonen, *A. atratae* (Savile) Kukkonen, *A. bigelowii* Nannf., *A. buxbaumii* Kukkonen, *A. capillaris* Kukkonen, *A. caricis* (Pers.) Bref., *A. caricis-albae* (Syd.) Kukkonen, *A. caricis-pauciflorae* (Lehtola) Kukkonen, *A. caryophylleae* Kukkonen, *A. echinospora* (Lehtola) Kukkonen, *A. elynae* (Syd.) Kukkonen, *A. fischeri* (P. Karst.) Kukkonen, *A. globularis* Kukkonen, *A. heterospora* (B. Lindeb.) Kukkonen, *A. humilis* Vánky, *A. intercedens* Nannf., *A. irregularis* (Liro) Boidol & Poelt, *A. karii* (Liro) Nannf., *A. lasiocarpae* B. Lindeb., *A. laxae* Kukkonen, *A. limosa* (Syd.) Kukkonen, *A. lindebergiae* (Kukkonen) Kukkonen, *A. liroi* (Lehtola) Nannf. & B. Lindeb., *A. michelii* Vánky, *A. misandrae* Kukkonen, *A. paniceae* Kukkonen, *A. pilosae* Vánky, *A. rupestris* Kukkonen, *A. scirpi* (J.G. Kühn) Kukkonen, *A. scirpoideae* Kukkonen, *A. siderostictae* Kukkonen, *A. subinclusa* (Körn.) Bref., and *A. variabilis* (S. Ito) Kakish. (Govorova 1987, 1990; Azbukina & al. 1995; Denchev & al. 2010, 2013, 2020; Denchev & Minter 2011). *Anthracoidea kenaica* is reported here for the first time from the Russian Far East and Asia.

Materials & methods

A dried specimen from the herbarium of the Royal Botanic Gardens, Kew (K) was examined under light microscope (LM) and scanning electron microscope (SEM). For LM observations and measurements, spores were mounted in lactoglycerol solution (w : la : gl = 1 : 1 : 2) on glass slides, gently heated to boiling point to rehydrate the spores, and then cooled. The spore measurements are given as min–max (extreme values) (mean ± 1 standard deviation). The spore length range is in accordance with the groups distinguished by Denchev & al. (2020: 11): very small-sized, small-sized, medium-sized, and large-sized. For SEM, spores were attached to

specimen holders by double-sided adhesive tape and coated with gold using an ion sputter coater. The surface structure of spores was observed and photographed at 10 kV accelerating voltage using a JEOL SM-6390 scanning electron microscope. The description of spore ornamentation is in accordance with Denchev & al. (2013). The description below is based entirely on the specimen examined. The list of shapes of spores is arranged in descending order of frequency.

Taxonomy

Anthracoidea kenaica (Savile) Piątek, IMA Fungus 4: 104, 2013. FIG. 1

≡ *Cintractia carpophila* var. *kenaica* Savile, Canad. J. Bot. 30: 419, 1952.

≡ *Anthracoidea heterospora* var. *kenaica* (Savile) Zambett., Bull. Soc. Mycol. France 94: 177, 1978.

INFECTION local. SORI in some female flowers, around aborted nuts as ovoid, black, hard bodies, 1.0–1.5 mm long, initially covered by a thin greyish peridium that later flakes away exposing a black spore mass, powdery on the surface. SPORES small- to medium-sized, flattened, in plane view suborbicular, broadly elliptical or ovate, in plane view (16–)17–21 (–23) × 13.5–18.5(–20) (19.3 ± 1.1 × 17.5 ± 1.5) µm (n = 100), in side view 12.0–15.5 µm thick, middle reddish brown, wall evenly or almost evenly thickened, 0.8–1.2(–1.5) µm thick, with 1–5 usually conspicuous internal swellings, light refractive areas and protuberances absent, some spores covered by a thin hyaline sheath, in LM smooth, spore profile not affected. In SEM, spore wall punctate, warts <0.1 µm (as measured in SEM). SPORE GERMINATION unknown.

SPECIMEN EXAMINED—On *Carex micropoda:* **RUSSIA, KAMCHATKA TERRITORY, Karaginsky Island** in the Bering Sea, Mt. Vysokaya, 22 August 1976, leg. S. Kharkevich & T. Buch, Plantae Vasculares Orientis Extremi Rossici, Flora Exsiccata, no. 972d (K, s.n.).

DISTRIBUTION—On *Cyperaceae: Carex micropoda,* Asia (Russian Far East) and North America (Saint Paul Island in the Bering Sea, Kenai Peninsula, and British Columbia) (FIG. 1).

COMMENTS—The morphological features given in the protologue of *A. kenaica* (Savile 1952, as '*Cintractia carpophila* var. *kenaica*') are similar to those reported here.

Carex micropoda is an amphi-Pacific/Beringian–Cordilleran species (Elven & al. 2018), distributed in the Russian Far East, Japan, islands of the Bering Sea, and western North American mountains (Egorova 1999, Murray 2002). Based on the current distribution data, *Anthracoidea kenaica* is an amphi-Beringian–Cordilleran species.

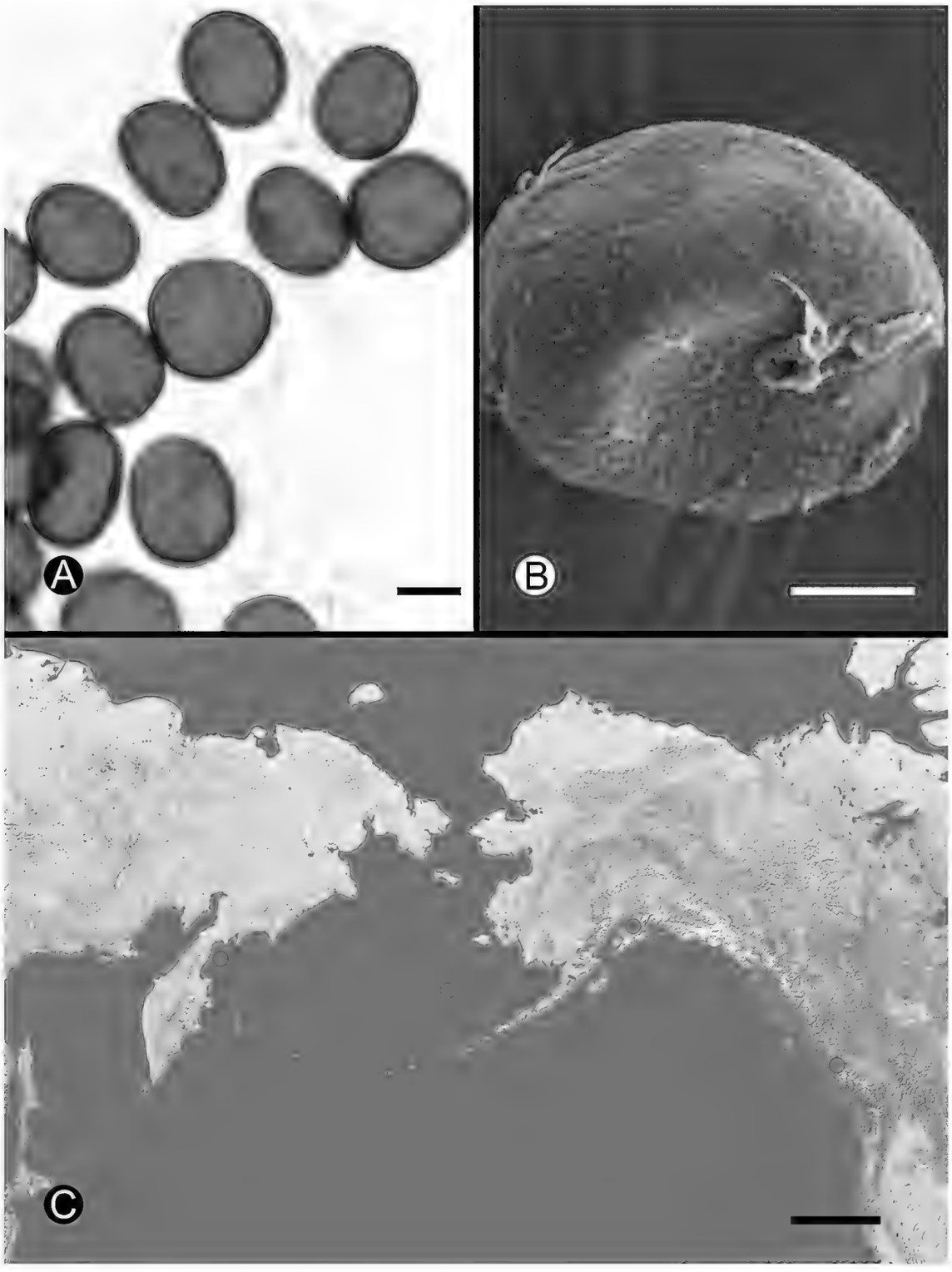


Fig. 1. *Anthracoidea kenaica* on *Carex micropoda* (Pl. Vascular. Orient. Extremi Rossici, Fl. Exs., no. 972d, K): A. Spores in LM; B. Spore in SEM; C. Geographic distribution (red circle = examined specimen, yellow circles = literature records). Scale bars: A = 10 µm, B = 5 µm, C = 1000 km.

Carex micropoda has been traditionally included either in *C.* sect. *Callistachys* (Heuff.) Mack. (Egorova 1999) or in *C.* sect. *Dornera* Heuff. (Murray 2002). A recently proposed classification of *Carex* places this sedge within the Pauciflora Clade of *C.* subgen. *Euthyceras* Peterm. (Roalson & al. 2021). The Pauciflora Clade is a heterogeneous group of unispicate sedges that includes the species of the previously recognized sections *Circinatae, Dornera,* and *Inflatae,* and the type of sect. *Leucoglochin, C. pauciflora* (Roalson & al. 2021). There are 14 sedges in this clade, among which only two species are reported as hosts of *Anthracoidea* species: *Carex breweri* Boott as host of *A. breweri* Salo & Vánky (Vánky 2011a) and *Carex pauciflora* as host of *A. caricis-pauciflorae* (Kukkonen 1963, Vánky 2011b). *Anthracoidea kenaica* differs from *A. breweri* and *A. caricis-pauciflorae* by having (i) smaller spores (small- to medium-sized), ≤23 µm long, while *A. breweri* and *A. caricis-pauciflorae* have medium- to large-sized spores (≤27 µm long); (ii) punctate spore ornamentation vs. minutely verruculose ornamentation for *A. breweri* and *A. caricis-pauciflorae;* and (iii) internal swellings, while the spores of *A. breweri* and *A. caricis-pauciflorae* have no internal swellings.

The protologue of *Cintractia carpophila* var. *kenaica* cites a second host plant, *Carex deweyana* Schwein. (Savile 1952: 420). The smut fungus on *C. deweyana,* however, possesses minutely verruculose spores and was later described as a distinct species, *Anthracoidea deweyanae* Denchev & T. Denchev (Denchev & Denchev 2012).

Acknowledgements

This study was supported by the Bulgarian National Science Fund (Grant no. KP-06-N51/10/16.11.2021). The authors gratefully acknowledge Prof. Makoto Kakishima (University of Tsukuba, Tsukuba, Japan) and Dr Eric H.C. McKenzie (Manaaki Whenua-Landcare Research, Auckland, New Zealand) for critically reading the manuscript and serving as pre-submission reviewers.

Literature cited

Azbukina ZM, Karatygin IV, Govorova, OK. 1995. *Ustomycetes* Moore. 9–205, in: ZM Azbukina (ed.), Plantae non vasculares, *Fungi* et *Bryopsida* orientis extremi rossica, Fungi, 3. Nauka, St. Petersburg. [In Russian]

Denchev CM, Denchev TT. 2012. New records of smut fungi. 7. Mycotaxon 121: 425–434. https://doi.org/10.5248/121.425

Denchev CM, Minter DW. 2011. *Anthracoidea siderostictae.* IMI Descriptions of Fungi and Bacteria, no. 1869. CAB International, Egham.

Denchev CM, Denchev TT, Karatygin IV. 2010. New records of smut fungi. 2. *Anthracoidea arnellii* sp. nov. Mycotaxon 114: 67–70. https://doi.org/10.5248/114.67

Denchev TT, Denchev CM, Michikawa M, Kakishima M. 2013. The genus *Anthracoidea* (*Anthracoideaceae*) in Japan and some adjacent regions. Mycobiota 2: 1–125. https://doi.org/10.12664/mycobiota.2013.02.01

Denchev TT, Knudsen H, Denchev CM. 2020. The smut fungi of Greenland. MycoKeys 64: 1–164. https://doi.org/10.3897/mycokeys.64.473800

Denchev TT, Denchev CM, Koopman J, Begerow D, Kemler M. 2021. Host specialization and molecular evidence support a distinct species of smut fungus, *Anthracoidea hallerianae* (*Anthracoideaceae*), on *Carex halleriana* (*Cyperaceae*). Willdenowia 51: 57–67. https://doi.org/10.3372/wi.51.51105

Egorova TV. 1999. The sedges (*Carex* L.) of Russia and adjacent states (within the limits of the former USSR). St. Petersburg State Chemical-Pharmaceutical Academy, St. Petersburg & Missouri Botanical Garden Press, St. Louis.

Elven R, Murray DF, Razzhivin VY, Yurtsev BA (eds) 2018. Annotated checklist of the Panarctic Flora (PAF). Vascular plants. Natural History Museum, University of Oslo. https://panarcticflora.org/ [last accessed 11 October 2021]

Govorova OK. 1987. Materials on the smut fungi (*Ustilaginaceae*) of the Soviet Far East. Novosti Sistematiki Nizshikh Rastenii 24: 100–106. [In Russian]

Govorova OK. 1990. Smut fungi of the Soviet Far East. Institute of Biology and Soil Science, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok. [In Russian]

Kukkonen I. 1963. Taxonomic studies on the genus *Anthracoidea* (*Ustilaginales*). Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 1–122.

Murray DF. 2002. *Carex* Linnaeus sect. *Dornera* Heuffel. 528–530, in: Flora of North America Editorial Committee (ed.), Flora of North America north of Mexico, vol. 23 (*Cyperaceae*). Oxford University Press, New York, Oxford.

Piątek M. 2013. The identity of *Cintractia carpophila* var. *kenaica:* reclassification of a North American smut on *Carex micropoda* as a distinct species of *Anthracoidea.* IMA Fungus 4: 103–109. https://doi.org/10.5598/imafungus.2013.04.01.10

Roalson EH, Jiménez-Mejías P, Hipp AL, Benítez-Benítez C, Bruederle LP, Chung KS & al. 2021. A framework infrageneric classification of *Carex* (*Cyperaceae*) and its organizing principles. Journal of Systematics and Evolution 59: 726–762. https://doi.org/10.1111/jse.12722

Savile DBO. 1952. A study of the species of *Cintractia* on *Carex, Kobresia,* and *Scirpus* in North America. Canadian Journal of Botany 30: 410–435. https://doi.org/10.1139/b52-032

Vánky K. 1979. Species concept in *Anthracoidea* (*Ustilaginales*) and some new species. Botaniska Notiser 132: 221–231.

Vánky K. 2011a. Seven new species of smut fungi (*Ustilaginomycotina*). Mycologia Balcanica 8: 97–104. https://doi.org/10.5281/zenodo.2550638

Vánky K. 2011b ["2012"]. Smut fungi of the world. APS Press, St. Paul, Minnesota, USA.

Zambettakis C. 1978. Les *Anthracoidea* des *Carex* et les Ustilaginées aberrantes. Bulletin de la Société Mycologique de France 94: 109–260.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 359–369

https://doi.org/10.5248/137.359

Nivicolous myxomycetes from the Navarran and French Pyrenees

Á. López-Villalba[1,2*], G. Moreno[1], M. Tapia[3]

[1] *Dpto. Ciencias de la Vida (Botánica), Facultad de Ciencias, Universidad de Alcalá, 28805 Alcalá de Henares, Madrid, Spain*

[2] *Institute of Botany and Landscape Ecology, Ernst Moritz Arndt University Greifswald, Soldmannstrasse 15, Greifswald, D-17487, Germany*

[3] *La Viña 6, 5º B, 31600 Burlada, Navarra, Spain*

* Correspondence to: *angela.lopez-villalba@uni-greifswald.de*

Abstract—Twenty-six collections of myxomycetes are reported from localities in northern Spain and southern France, representing nine species: *Diderma alpinum*, *D. europaeum*, *D. fallax*, *D. meyerae*, *Lamproderma ovoideum*, *L. sauteri*, *Lepidoderma peyerimhoffii*, *Meriderma echinulatum*, and *Physarum vernum*. The LM and SEM micrographs included illustrate the most representative characters of each species.

Key words—*Amoebozoa*, myxobiota, *Myxogastria*, slime moulds, taxonomy

Introduction

Different species of nivicolous myxomycetes are described herein. These were collected in northern Spain in Belagua Valley (also known as Roncal Valley) in the north-western part of the Pyrenees; and in southern France at La Pierre San Martín ski resort in the French continuation of the Roncal Valley (Fig. 1).

The Spanish area is covered by a beech–fir forest accompanied by *Pinus uncinata* Ramond ex DC., *Rhododendron ferrugineum* L., *Vaccinium myrtillus* L., and *Juniperus communis* var. *alpina* Gaudin. The sampling elevation varied from 1700 to 2000 m, while the French samples were collected at 1500 to 2200 m.

FIG. 1 The study area covered during the research.

The diversity of nivicolous myxomycetes in these areas is poorly known, and all collections presented here constitute new records for both locations.

Materials & methods

The material studied and the slides mounted in Hoyer's medium for each specimen are preserved in the herbarium of the Universidad de Alcalá, Alcalá de Henares, Madrid, Spain (AH).

Spore measurements were made using an oil immersion objective and include surface structures such as warts and spines.

Scanning electron microscopy (SEM) micrographs were obtained at the Universidad de Alcalá using a Zeiss DSM-950. For ultramicroscopic studies, one sporocarp was placed on a 2 × 2 cm square of Whatman filter paper no. 2; the paper was folded into a packet to prevent the loss of spores and stapled shut, after which the packeted specimen was rehydrated in concentrated ammonium hydroxide (28–30%) for 30 minutes, dehydrated in aqueous ethanol (70%) for 30 minutes, fixed for two hours in pure ethylene glycol dimethyl ether (= 1,2-dimethoxymethane), immersed in pure acetone for at least two hours, and finally critically point dried and sputtered with gold-palladium. This technique uses very little material (a portion of a single sporocarp or no more than a few spores).

Taxonomy

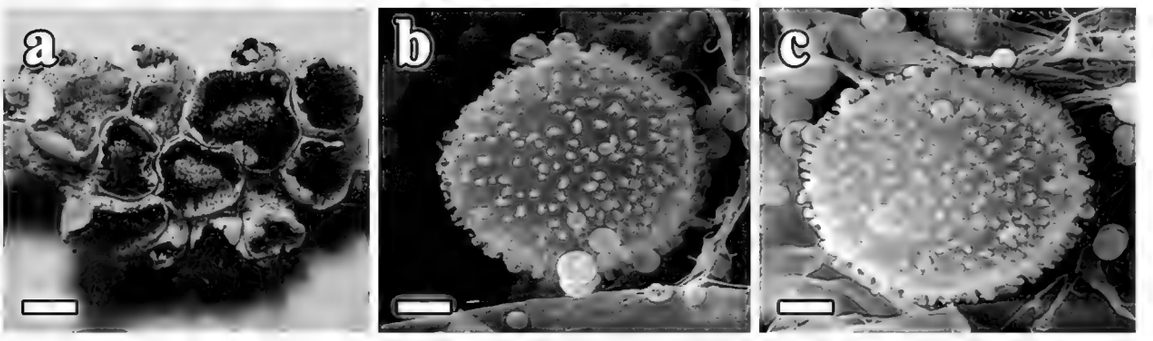


Fig. 2 *Diderma alpinum* (AH 50407): a. Sporocarps; b. Spore; c. Spore ornamentation (detail). Scale bars: a = 1 mm; b, c = 2 μm.

Diderma alpinum (Meyl.) Meyl., Bull. Soc. Vaud. Sci. Nat. 51: 261. 1917 Fig. 2

The capillitium of the specimens is hyaline to slightly grey under the stereomicroscope, the pseudocolumella is prominent and orange, and the spore ornamentation consists of abundant and regularly distributed spines.

Specimens examined: **FRANCE, Pyrénées-Atlantiques, Arette,** La Pierre San Martín ski resort, herbaceous debris, 26–v–2018, leg. M. Tapia 180526–020 (AH 50407); **SPAIN, Navarra, Isaba,** Belagua Valley, woody debris, 8–v–2018, leg. M. Tapia 180508–039 (AH 50410); on *Erica* sp. woody debris, 8–v–2018, leg. M. Tapia 180508–025 (AH 50416).

Remarks—The aforementioned characters are typical among Spanish collections of *Diderma alpinum*. Nonetheless, Kuhnt (2009) described it as a plasmodiocarpic species and reported it as such in his photographs. Future molecular studies are needed to disentangle the complex involving *D. alpinum*, *D. niveum* (Rostaf.) E. Sheld., *D. microcarpum* Meyl., and other closely related species.

Diderma alpinum is a common species in the Northern Hemisphere (https://www.gbif.org).

Diderma europaeum (Buyck) Kuhnt, Ber. Bayer. Bot. Ges. 87: 111. 2017 Fig. 3

The two examined specimens are representative of the species due to their globose to subglobose and clustered to (rarely) scattered sporocarps, sometimes with remains of a whitish hypothallus. Peridium double, externally white. Capillitium hyaline, emerging radially from the pseudocolumella. Pseudocolumella white, prominent, with warts on the surface. Spores violaceous-brown, globose to subglobose, 11–12 μm in diam., spinose.

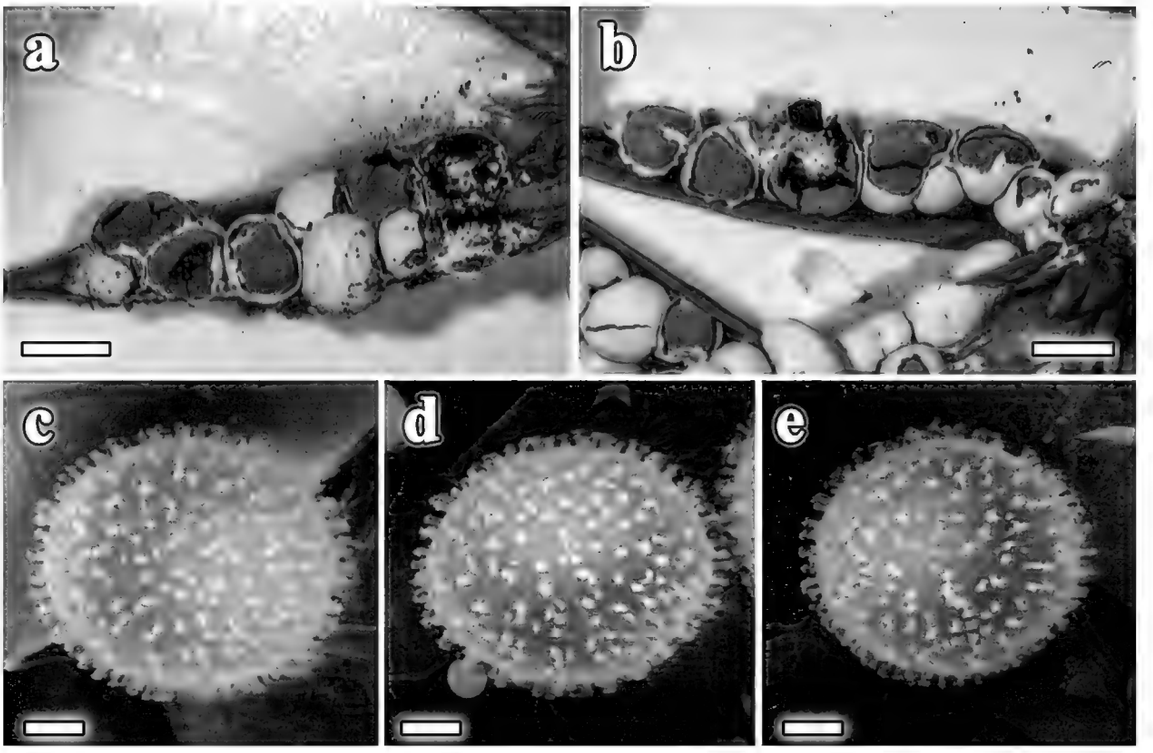


Fig. 3 *Diderma europaeum* (AH 50414): a, b. Sporocarps; c–e. Spores. Scale bars: a, b = 1 mm; c–e = 2 µm.

Specimens examined: **SPAIN, Navarra, Isaba,** Belagua Valley, *Juniperus communis* var. *alpina* leaves, 8-v-2018, leg. M. Tapia 180508-032 (AH 50414); on twigs, 10-vi-2018, leg. M. Tapia 180610-043 (AH 50497).

Remarks—A representative photograph of *Diderma europaeum* can be found in Poulain & al. (2011). This species has been widely cited, especially in Central Europe and northern Spain (https://www.gbif.org).

Diderma fallax (Rostaf.) E. Sheld., Minnesota Bot. Stud. 1: 477. 1895 Fig. 4

The specimens examined are characterized by clustered sporocarps, a double peridium, and a prominent, club-shaped pseudocolumella. The outer peridium breaks easily in polygonal plates, allowing the inner, membranous peridium to be visible. On the inner peridium, remains of globular crystals from the outer peridium can be observed. Capillitium with abundant, radial threads, black colored, and with nodules (3–5 µm diam.) visible under transmitted light. Spores dark violaceous-brown under transmitted light, globose to subglobose, 14–16 µm in diam., spinose. Under SEM, the spore ornamentation is seen as lax, irregularly distributed spines, occasionally with coralloid tips.

The peridium in AH 50402 is decarbonated, although the globular crystals of calcium carbonate can be observed under transmitted light.

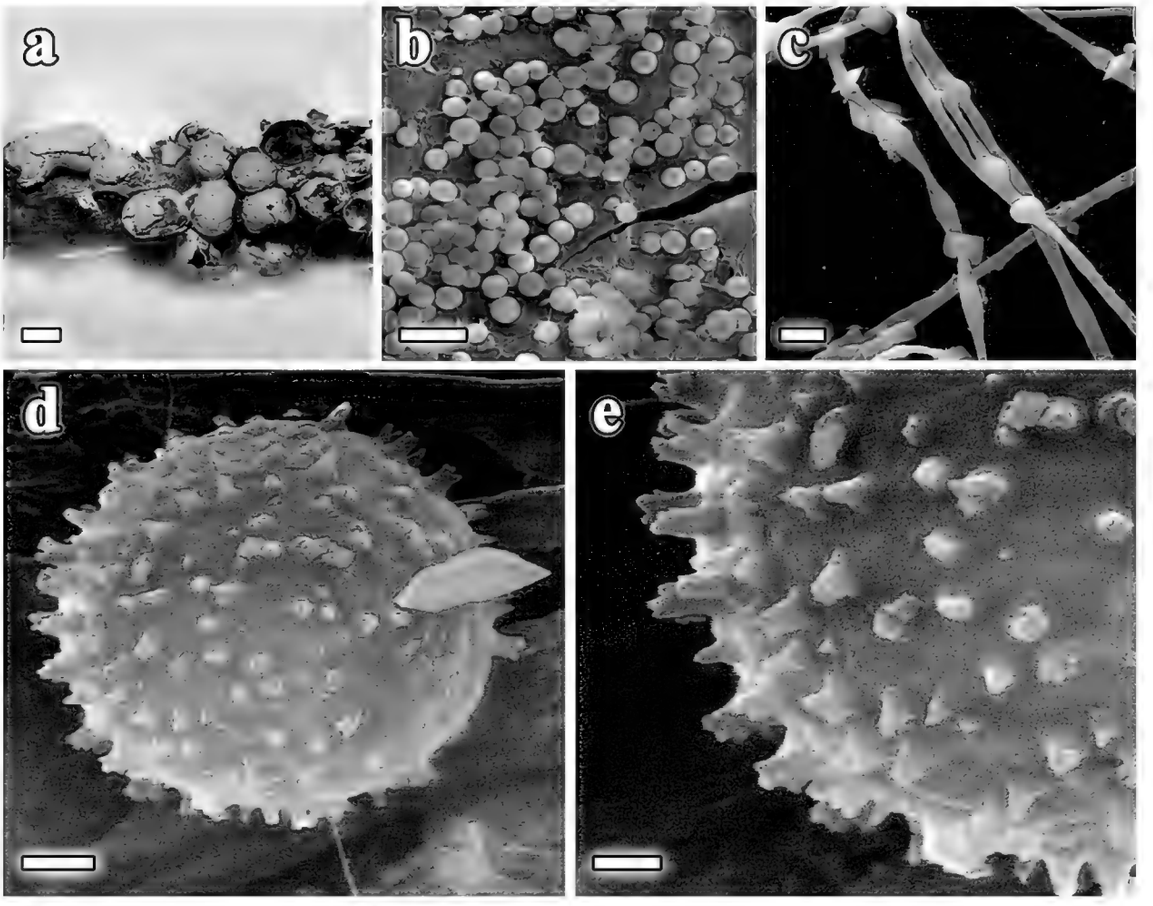


Fig. 4 *Diderma fallax* (AH 50403): a. Sporocarps; b. Inner peridium with globular crystals of calcium carbonate; c. Capillitium; d. Spore; e. Spore ornamentation (detail). Scale bars: a = 1 mm; b, c = 5 µm; d = 2 µm; e = 1 µm.

Specimens examined: **FRANCE, Pyrénées-Atlantiques, Arette,** La Pierre San Martín ski resort, herbaceous debris, 26-v-2018, leg. M. Tapia 180526-017 (AH 50403); leg. M. Tapia 180526-011 (AH 50402); **SPAIN, Navarra, Isaba,** Belagua Valley, herbaceous debris, 8-v-2018, leg. M. Tapia 180508-035 (AH 50413); 15-vi-2018, leg. M. Tapia 180615-001 (AH 50499).

Remarks—*Diderma fallax* has been widely confused with similar species of *Lepidoderma* de Bary, including *L. peyerimhoffii, L. nevadense* G. Moreno & al., and *L. echinosporum* G. Moreno & al. The taxonomic treatment used herein follows Moreno & al. (2018b). *Diderma fallax* can be distinguished from any other *Lepidoderma* species, thanks to the globular calcium carbonate that forms the external peridium, absent in *Lepidoderma.*

Diderma meyerae H. Singer, G. Moreno, Illana & A. Sánchez, Cryptog. Mycol. 24(1): 53. 2003. Fig. 5

The specimens examined have whitish to creamy sporangia, clustered, with a double peridium, and a globose, prominent, verrucose, orange

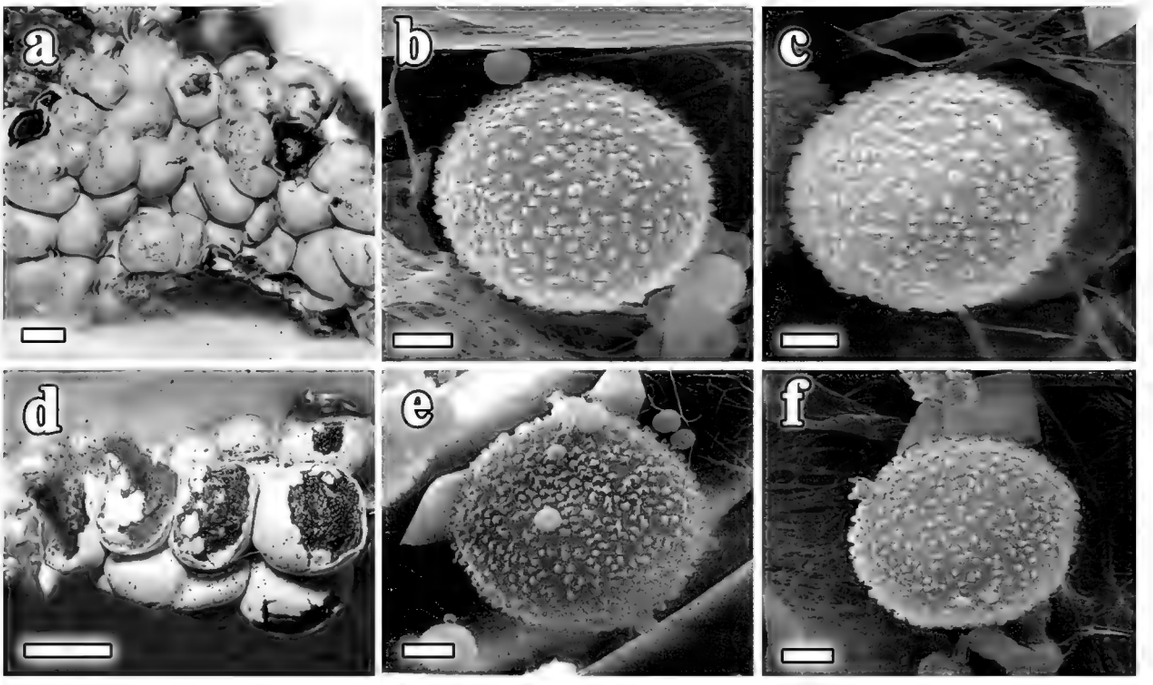


Fig. 5 *Diderma meyerae* (AH 50500 & AH 50502): a, d. Sporocarps; b, c, e, f. Spores. Scale bars: a, d = 1 mm; b, c, e, f = 2 μm.

pseudocolumella. Capillitium with blackish threads, emerging radially from the pseudocolumella. Spores violaceous-brown in transmitted light, globose to subglobose, 10–13 μm in diam., with thick warts. Under SEM, the ornamentation of the spores is also verrucose, but some short crests become apparent.

Specimens examined: **SPAIN, Navarra, Isaba,** Belagua Valley, herbaceous debris, 8-v-2018, leg. M. Tapia 180508-029 (AH 50408); 15-vi-2018, leg. M. Tapia 180615-010 (AH 50502); on *Erica* sp. leaves and inflorescences, 15-vi-2018, leg. M. Tapia 180615-003 (AH 50500); on vegetal debris and *Erica* sp. leaves, 15-vi-2018, leg. M. Tapia 180615-004 (AH 50501).

Remarks—The spore ornamentation consists of thick warts that sometimes join in low crests. This key character distinguishes *Diderma meyerae* from other morphologically similar species, such as *Diderma niveum* and *D. alpinum,* both of which develop bacula on their spores (Moreno & al. 2003).

Lamproderma ovoideum Meyl., Bull. Soc. Vaud. Sci. Nat. 57: 370. 1932 Fig. 6

Sporocarps short-stalked, grouped, 1.1–1.5 × 0.9–1.2 mm, with ovoid sporothecas. Capillitium brown, paler at the periphery, branched and anastomosed, not emerging radially from the columella. Spores dark brown with a paler area, globose to subglobose, 12–15 μm in diam., with very faint warts or spinules.

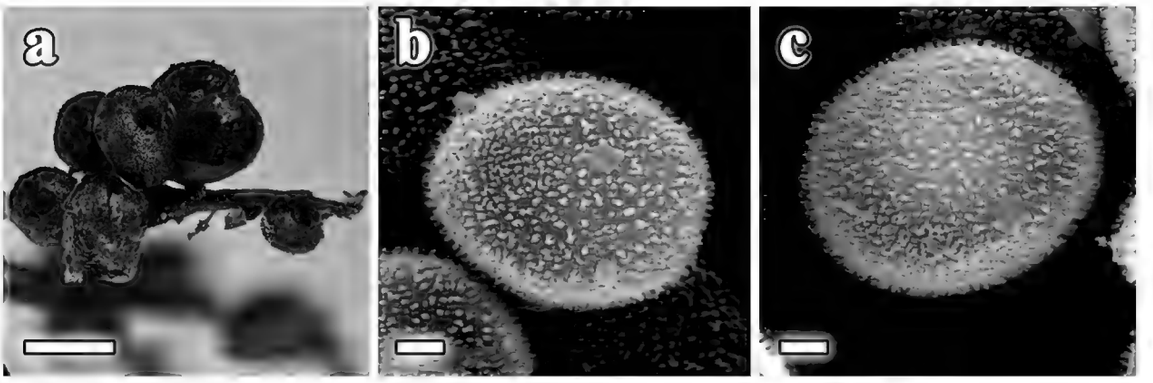


Fig. 6 *Lamproderma ovoideum* (AH 50415): a. Sporocarps; b, c. Spores. Scale bars: a = 1 mm; b, c = 2 µm.

Specimen examined: **SPAIN, Navarra, Isaba,** Belagua Valley, herbaceous debris, 8-v-2018, leg. M. Tapia 180508-027 (AH 50415).

Remarks—*Lamproderma ovoideum* is characterized by the ovoid sporotheca, short stalk, iridescent and blackish peridium, and 12–15 µm spores. *Lamproderma piriforme* (Meyl.) Mar. Mey. & Poulain can be distinguished by its larger (16–19.5 µm diam.) spores.

Lamproderma sauteri Rostaf., Sluzowce Monogr.: 205. 1874 Fig. 7

The specimens examined show crowded and stalked sporocarps, 1.5–2 × 0.7–1 mm. Stalk cylindrical, with length approximately the same as the diameter of the sporotheca (0.5–1 mm). Peridium membranous, violaceous-blue, iridescent. Capillitium emerging radially from the apex of the sporotheca, brown, paler in the periphery. Spores brown in transmitted light, globose to subglobose, 12–14 µm in diam., spinulose. Under SEM, the spore ornamentation consists of abundant and densely arranged bacula, occasionally creating short crests.

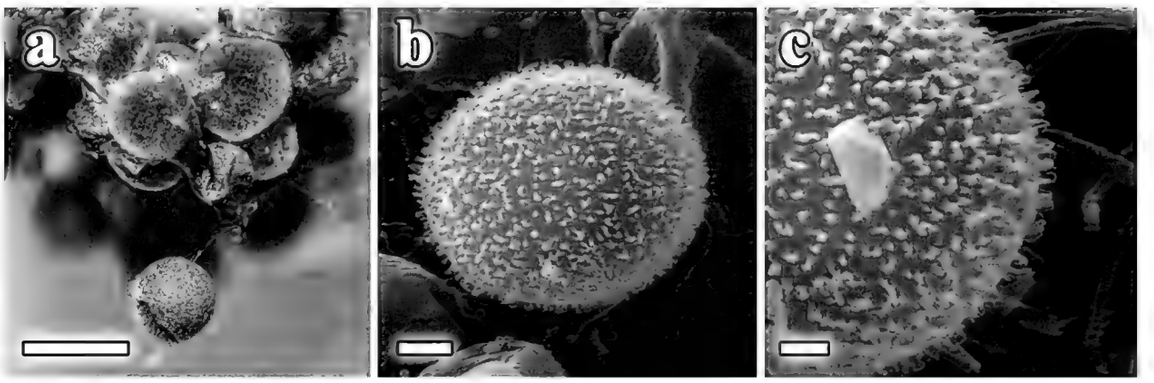


Fig. 7 *Lamproderma sauteri* (AH 50404): a. Sporocarps; b. Spore; c. Spore ornamentation (detail). Scale bars: a = 1 mm; b = 2 µm; c = 1 µm.

Specimens examined: **FRANCE, Pyrénées-Atlantiques, Arette,** La Pierre San Martín ski resort, on moss, 22-v-2018, leg. M. Tapia 180522-009 (AH 50495); **SPAIN, Navarra, Isaba,** Belagua Valley, on moss, 8-v-2018, leg. M. Tapia 180508-046 (AH 50404).

Remarks—*Lamproderma sauteri* can be confused with *Lamproderma splendidissimum* Mar. Mey. & al. and *Lamproderma splendens* Meyl. *Lamproderma splendidissimum* is characterized by the bright blue sporocarps, the shorter stalks (less than the height of the sporotheca), and the spinulose spores measuring 11–12 µm in diam. (Poulain & al. 2014). *Lamproderma splendens* can be easily distinguished from *Lamproderma sauteri* due to the verrucose spores.

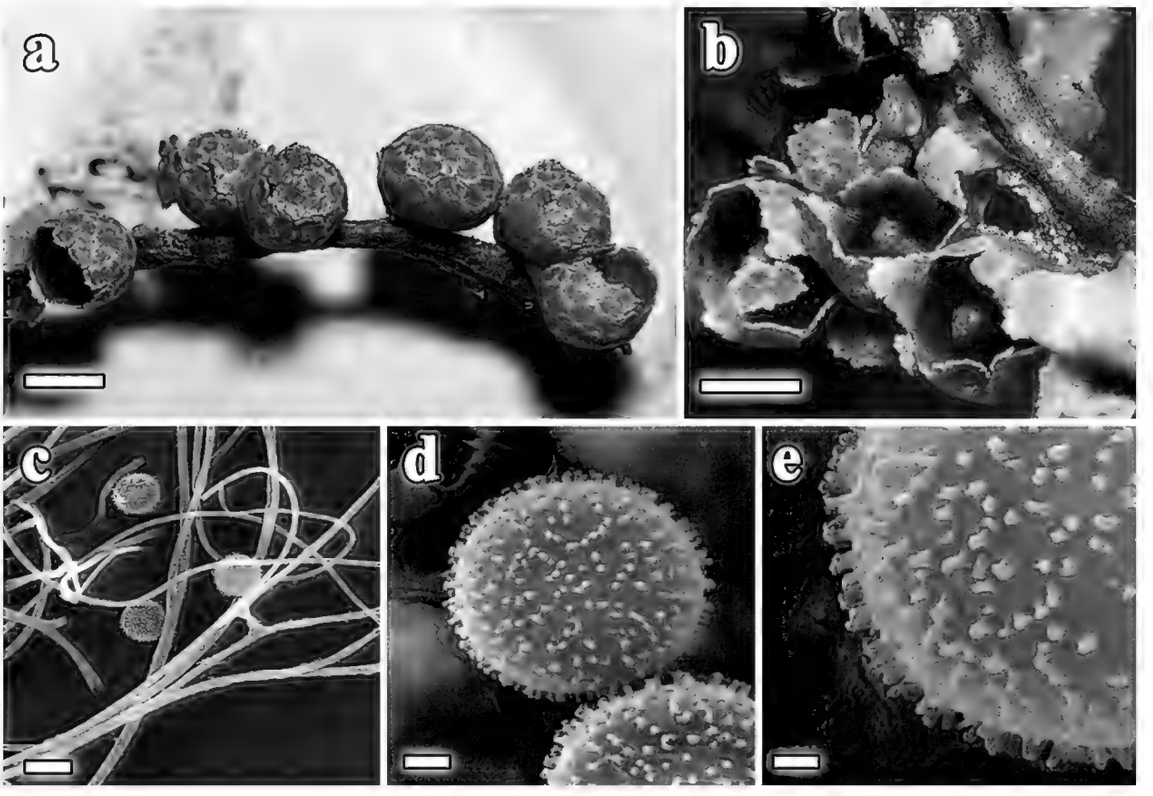


Fig. 8 *Lepidoderma peyerimhoffii* (AH 50503): a. Sporocarps; b. Peridium broken in polygonal plates; c. Capillitium; d. Spore; e. Spore ornamentation (detail).
Scale bars: a, b = 1 mm; c = 10 µm; d = 2 µm; e = 1 µm.

Lepidoderma peyerimhoffii Maire & Pinoy,
Bull. Soc. Hist. Nat. Afrique N. 17(1): 40. 1926 Fig. 8

The specimens studied were the typically reddish-brown grouped sporocarps. Peridium triple—an outer layer with brown lime scales that break into polygonal plates, white at the edges; an intermediate layer formed by white lime scales; and an inner layer as a hyaline, iridescent membrane. Pseudocolumella prominent, club-shaped, dark orange; sometimes with

scales resembling those of the peridium. Capillitium formed by dark brown threads that emerge radially from the pseudocolumella, threads ramified and with widenings. Spores dark violaceous-brown in transmitted light, globose to subglobose, 12–15 µm in diam., densely spinose.

Specimens examined: **FRANCE, Pyrénées-Atlantiques, Arette,** La Pierre San Martín ski resort, herbaceous debris, 26-v-2018, leg. M. Tapia 180526-008 (AH 50405); **SPAIN, Navarra, Isaba,** Belagua Valley, on shrub debris, 15-vi-2018, leg. M. Tapia 180615-008 (AH 50503).

Remarks—The *Lepidoderma peyerimhoffii* specimens collected for this work remind one of those studied by Moreno & al. (2018b), where photographs of the type were taken.

Meriderma echinulatum (Meyl.) Mar. Mey. & Poulain,
Myxomycètes 551. 2011 Fig. 9

The specimen comprises sessile or short-stalked sporocarps with ovoid sporothecas, 1–1.2 × 0.9–1.1 mm. Capillitium emerging as threads along the whole columella, dark brown, dense, with funnel-shaped ends attached to a piece of the peridium. Columella with a globose to swollen apex. Spores dark brown in transmitted light, globose to subglobose, 12–15 µm in diam,

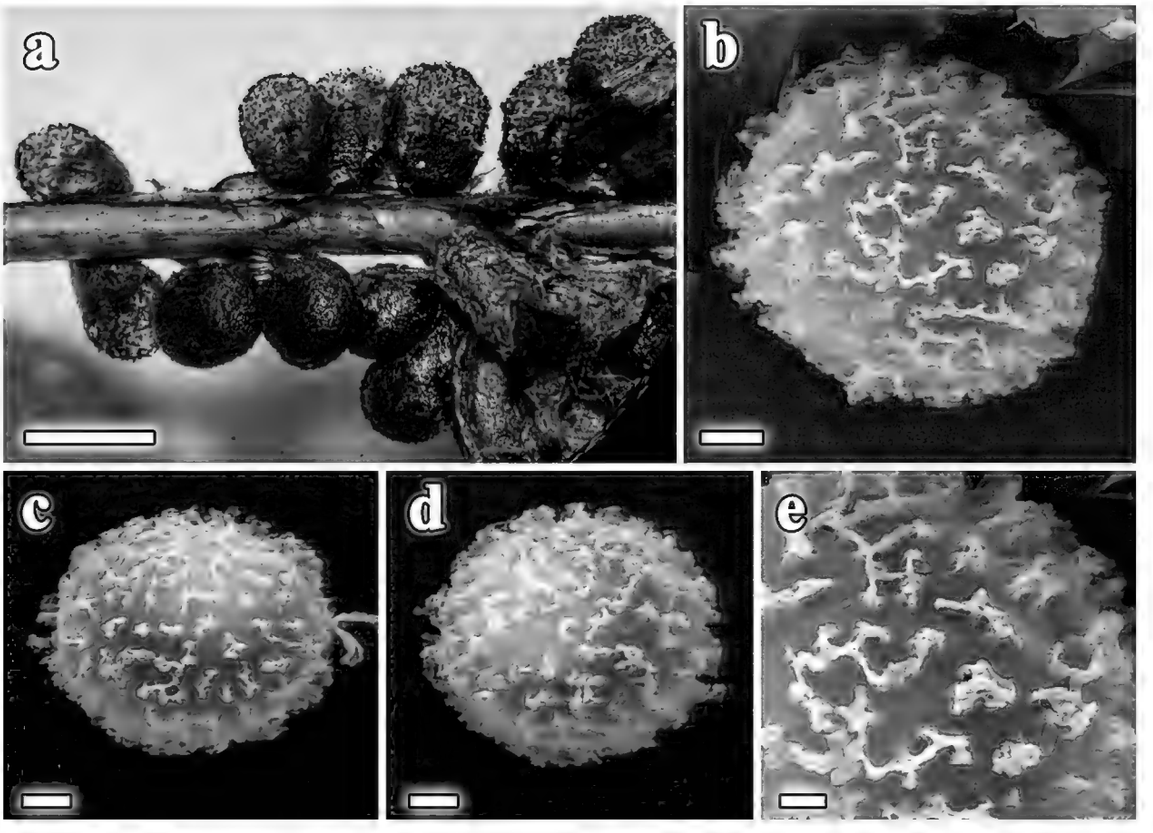


Fig. 9 *Meriderma echinulatum* (AH 50400): a. Sporocarps; b–d. Spores; e. Spore ornamentation (detail). Scale bars: a = 1 mm; b–d = 2 µm; e = 1 µm.

with prominent, irregular, and sinuous crests. The SEM confirmed the ornamentation showing solid walls lacking holes or pits) and with crests occasionally creating a small subreticulum with widened areas.

Specimen examined: **FRANCE, Pyrénées-Atlantiques, Arette,** La Pierre San Martín ski resort, herbaceous debris, 22-v-2018, leg. M. Tapia 180522-018P1 (AH 50400).

Remarks—*Meriderma echinulatum* is well delimited by its spore ornamentation. The lectotype, studied by Moreno & al. (2002), shows an ornamentation that matches with the SEM micrographs of the current study as well as with Meylan's definition (Meylan 1932). Janik & Ronikier's (2016) spores of *M. echinulatum* had a denser and subreticulate ornamentation.

Physarum vernum Sommerf., in Fries, Syst. Mycol. 3(1): 146. 1829 Fig. 10

The specimens are developed in the form of long plasmodiocarps. Peridium double, consisting of an inner membrane covered by an outer layer of white calcium carbonate. Capillitium abundant, white, with fusiform to subglobose nodules. Spores dark violaceous-brown by transmitted light, globose to subglobose, 11–13 µm diam., spiny.

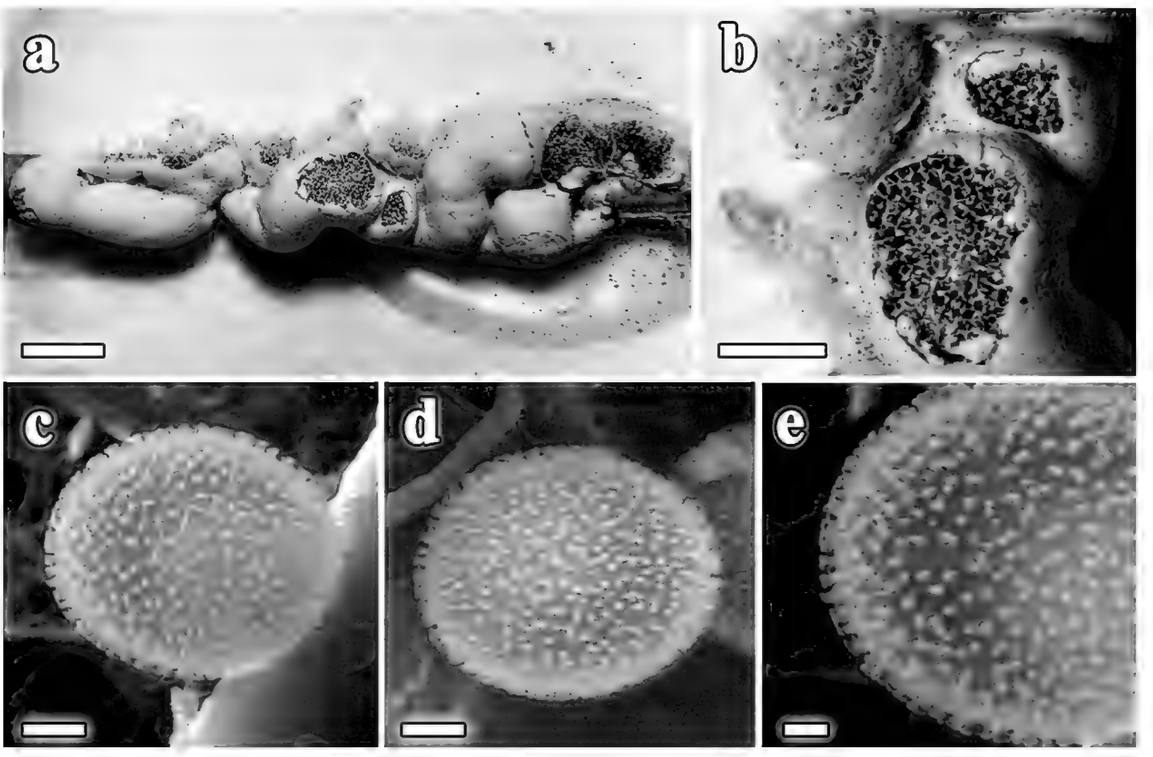


Fig. 10 *Physarum vernum* (AH 50401):
a. Sporocarps; b. Detail of the capillitium; c, d. Spores; e. Spore ornamentation (detail).
Scale bars: a = 1 mm; b = 0.5 mm; c, d. = 2 µm; e = 1 µm.

Specimens examined: **SPAIN, Navarra, Isaba,** Belagua Valley, on soil, 8–v–2018, leg. M. Tapia 180508–022 (AH 50399); on *Genista hispanica* subsp. *occidentalis* Rouy, 8–v–2018, leg. M. Tapia 180508–044 (AH 50409); herbaceous debris, 8–v–2018, leg. M. Tapia 180508–037 (AH 50411); leg. M. Tapia 180508–018 (AH 50412); 10–vi–2018, leg. M. Tapia 180610–003 (AH 50498); **FRANCE, Pyrénées-Atlantiques, Arette,** La Pierre San Martín ski resort, herbaceous debris, 26–v–2018, leg. M. Tapia 180526–007 (AH 50401); leg. M. Tapia 180526–021 (AH 50406).

Remarks—A detailed description of *Physarum vernum* can be found in Moreno & al. (2018a). This species is widely distributed throughout the Northern Hemisphere (https://discoverlife.org).

Acknowledgments

We wish to express our gratitude to Mr. A. Priego and Mr. J.A. Pérez (Electron Microscopy Service, Universidad de Alcalá) for their invaluable help with the SEM. We extend thanks to Luis Monje and Ángel Pueblas (Department of Drawing and Scientific Photography, Universidad de Alcalá) for their help in the digital preparation of the photographs, to Dr. Maria Martha Dios (University Nacional de Catamarca, San Fernando del Valle de Catamarca, Catamarca, Argentina) and Dr. Steven L. Stephenson (University of Arkansas, Fayetteville, AR, USA) for their revisions of the manuscript, and to Dr. J. Rejos, curator of the AH herbarium, for his assistance with the specimens examined in the present study.

Literature cited

Janik P, Ronikier A. 2016. *Meriderma* species (myxomycetes) from the Polish Carpathians: a taxonomic revision using SEM-visualized spore ornamentation. Acta Societatis Botanicorum Poloniae 85(3492): [13 p.]. https://doi.org/10.5586/asbp.3492

Kuhnt A. 2009. Nivicole Myxomyceten aus Deutschland (unter besonderer Berücksichtigung der bayerischen Alpen). Teil IV. Zeitschrift für Mykologie 75(2): 189–230.

Meylan C. 1932. Les espèces nivales du genre *Lamproderma*. Bulletin de la Société Vaudoise des Sciences Naturelles 57(228): 359–373.

Moreno G, Sánchez A, López-Villalba Á, Monje L, Castillo A. 2018a. First records of nivicolous *Myxomycetes* for Teide National Park, Tenerife, Canary Islands. Boletín de la Sociedad Micológica de Madrid 42: 11–19.

Moreno G, Sánchez A, Meyer M, López-Villalba Á, Castillo A. 2018b. Revision of the nivicolous species of the genus *Lepidoderma*. Boletín de la Sociedad Micológica de Madrid 42: 39–77.

Moreno G, Sánchez A, Singer H, Illana C, Castillo A. 2002. A study on nivicolous *Myxomycetes*. The genus *Lamproderma* I. Fungi Non Delineati 19: 1–66.

Moreno G, Singer H, Illana C, Sánchez A. 2003. SEM-studies on nivicolous *Myxomycetes*. The *Diderma niveum* complex in Europe. Cryptogamie, Mycologie 24(1): 39–58.

Poulain M, Meyer M, Bozonnet J. 2011. Les Myxomycètes. Fédération Mycologique et Botanique Dauphiné-Savoie. 568 p., 544 pl.

Poulain M, Meyer M, Bozonnet J. 2014. *Lamproderma splendidissimum*, une nouvelle espèce nivicole de myxomycètes. Bulletin de la Fédération Mycologique et Botanique Dauphiné-Savoie 213: 5–16.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 371–380

https://doi.org/10.5248/137.371

First Russian records of *Stemonitis rhizoideipes* and *Fuligo aurea*, and newly observed morphology for *Comatricha anomala*

Anastasia V. Vlasenko[1]*, Nina V. Filippova[2],
Vyacheslav A. Vlasenko[1]

[1] *Laboratory of Mycology, Algology and Lichenology, Central Siberian Botanical Garden, Siberian Branch, Russian Academy of Sciences, Novosibirsk, 630090, Russia*

[2] *Yugra State University, Khanty-Mansiysk, 628012, Russia*

* Correspondence to: *anastasiamix81@mail.ru*

Abstract—Three rare species of myxomycetes have been collected from Khanty-Mansi Autonomous Okrug–Yugra, Russia. *Stemonitis rhizoideipes* and *Fuligo aurea* were recorded for the first time in Russia and for the second time in extratropical Eurasia, and *Comatricha anomala* was recorded from a second Russian location. Thirty-three *S. rhizoideipes* specimens were isolated from bark of *Abies sibirica*, *Picea obovata*, and *Pinus sibirica* in moist chambers, while *F. aurea* plasmodiocarps were retrieved from *A. sibirica* bark in one Petri dish. We publish an emended description of *Comatricha anomala* after discovering new morphological features. Light and scanning electron micrographs and comparisons with morphologically similar taxa are presented for the three species.

Key words—*Myxogastria, Physaraceae*, SEM, *Stemonitidaceae*

Introduction

Myxomycetes are protists usually present in terrestrial ecosystems and constitute a well-defined and homogenous group of approximately 1000 species (Lado 2021). Large fruiting myxomycete bodies (known as sporocarps) can be collected in the field. The moist chamber culture technique, widely used to study myxomycete species with small fruiting bodies, is a highly efficient technique to reveal hidden diversity of epiphytic myxomycetes (Gilbert & Martin 1933, Härkönen 1977, Vlasenko & Vlasenko 2020).

Two rare myxomycete species, *Stemonitis rhizoideipes* and *Fuligo aurea*, have been recorded for the first time in Russia, and *Comatricha anomala* has been recorded from a second Russian location. All three species are described below.

Materials & methods

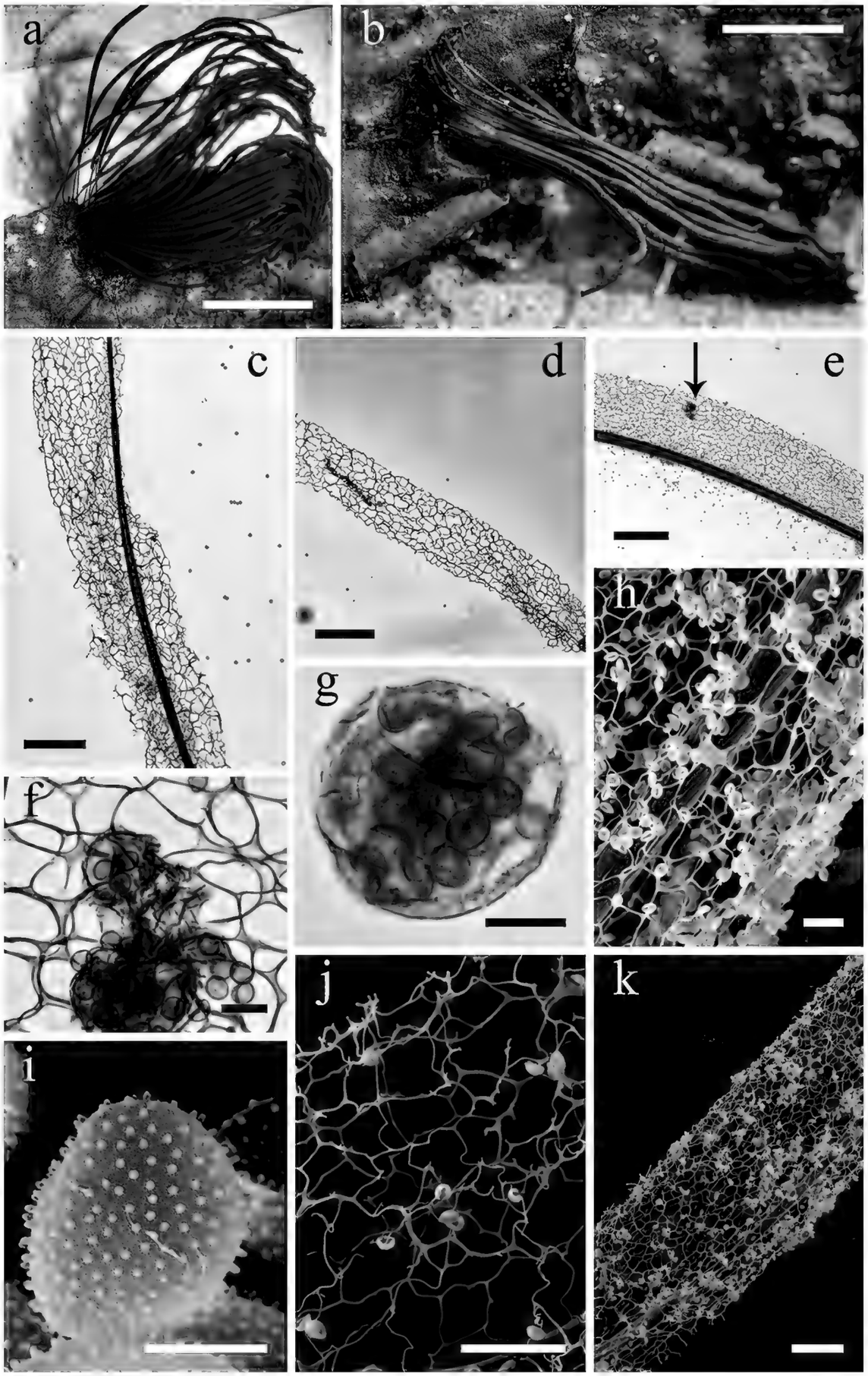
Specimens and samples were collected from two sites in the Khanty-Mansiysky district of Khanty-Mansi Autonomous Okrug–Yugra: (1) 22 km north-east of Khanty-Mansiysk, near Shapsha settlement; (2) 22 km south-west of Khanty-Mansiysk, near the Mukhrino Field Station of Ugra State University. Microscopical observations were made using a Stemi DV4 stereomicroscope, Axiolab E-re, and Zeiss Axio Imager A1 light microscopes, and a Carl Zeiss EVO MA 10 scanning electron microscope. Descriptions use the abbreviations TL = transmitted light and RL = reflected light. Specimens were conserved in the MG Popov Herbarium, Central Siberian Botanical Garden, Siberian Branch of Russian Academy of Sciences, Novosibirsk, Russia (NSK).

Taxonomy

Stemonitis rhizoideipes Nann.-Bremek., R. Sharma & K.S. Thind,
Proc. K. Ned. Akad. Wet., Ser. C, Biol. Med. Sci. 87(4): 465 (1984) Fig. 1

Sporocarps tufted, cylindrical, always bent or recumbent, 15–25 mm tall overall, brown. Sporotheca long cylindrical, 10–20 × 0.5–0.7 mm. Hypothallus often in tufts, red-brown, shiny with rhizoid-like thickenings where merging with stalk. Stalk short, black in RL, brown or red-brown in TL, 1–5 mm long, merging with hypothallus by rhizoid-like strands. Peridium fugacious except for some smooth, rounded or oval flakes that cling to surface but not attached to capillitium; shiny brown in RL, transparent pale brown in TL. Columella always dispersing into capillaries before reaching the apex. Capillitium brown, forming a lax net around columella, axils with membrane expansions, meshes irregular, 30–275 μm diam., free ends forming short spikes; capillitial net connected to columella only at the base and (rarely) at the apex; elsewhere the capillitium is free and not attached to columella, enabling the net of capillitial threads to move freely without damaging the columella. Spore mass brown. Spores pale brown, globose, warted, 8–10 μm diam; in SEM spore ornamentation comprising regularly distributed warts with dense or delicate reticulum sometimes forming between warts.

Fig. 1. *Stemonitis rhizoideipes* (NSK 1030488): a, b. Sporangia (RL); c, d. Capillitium (TL); e. Capillitium, arrow indicates the peridial remnants (TL); f. peridial remnants, spores (TL); g. Capillitium, peridial remnants, spores (TL); h. Capillitium, spores (SEM); i. Spore (SEM); j. Capillitium at the sporotheca apex, spores (SEM); k. Capillitium, spores (SEM). Scale bars: a, b = 5 mm; c–e = 200 μm; f, g = 20 μm; h = 30 μm; i = 5 μm; j, k = 100 μm.


a
b
c
d
e
f
g
h
i
j
k

Specimens examined: **RUSSIAN FEDERATION, Khanty-Mansi Autonomous Okrug–Yugra, Khanty-Mansiysky district,** 22 km north-east of Khanty-Mansiysk, near Shapsha settlement, 61.0808°N 69.4519°E, 43 m, old-aged coniferous mixed forest, on bark of living *Picea obovata*, substrate samples collected 27 September 2017, N.V. Filippova, moist chamber culture 05 January 2018, cult. and ident. A.V. Vlasenko (NSK 1030488); 61.0664°N 69.4689°E, 40 m, secondary deciduous forest, on bark of living *Abies sibirica*, substrate samples collected 28 September 2017, N.V. Filippova, moist chamber culture 31 January 2018, cult. and ident. A.V. Vlasenko (NSK 1030351); on bark of living *Picea obovata*, substrate samples collected 28 September 2017, N.V. Filippova, moist chamber culture 10 March 2019, cult. and ident. A.V. Vlasenko (NSK 1030493); 22 km south-west of Khanty-Mansiysk, near the Mukhrino Field Station of Ugra State University, old-aged coniferous mixed forest, 60.8906°N 68.7031°E, 37 m, on bark of living *Picea obovata*, substrate samples collected 19 October 2017, N.V. Filippova, moist chamber culture 10 March 2019, cult. and ident. A.V. Vlasenko (NSK 1030372); on bark of living *Abies sibirica*, substrate samples collected 19 October 2017, N.V. Filippova, moist chamber culture 22 March 2019, cult. and ident. A.V. Vlasenko (NSK 1030530).

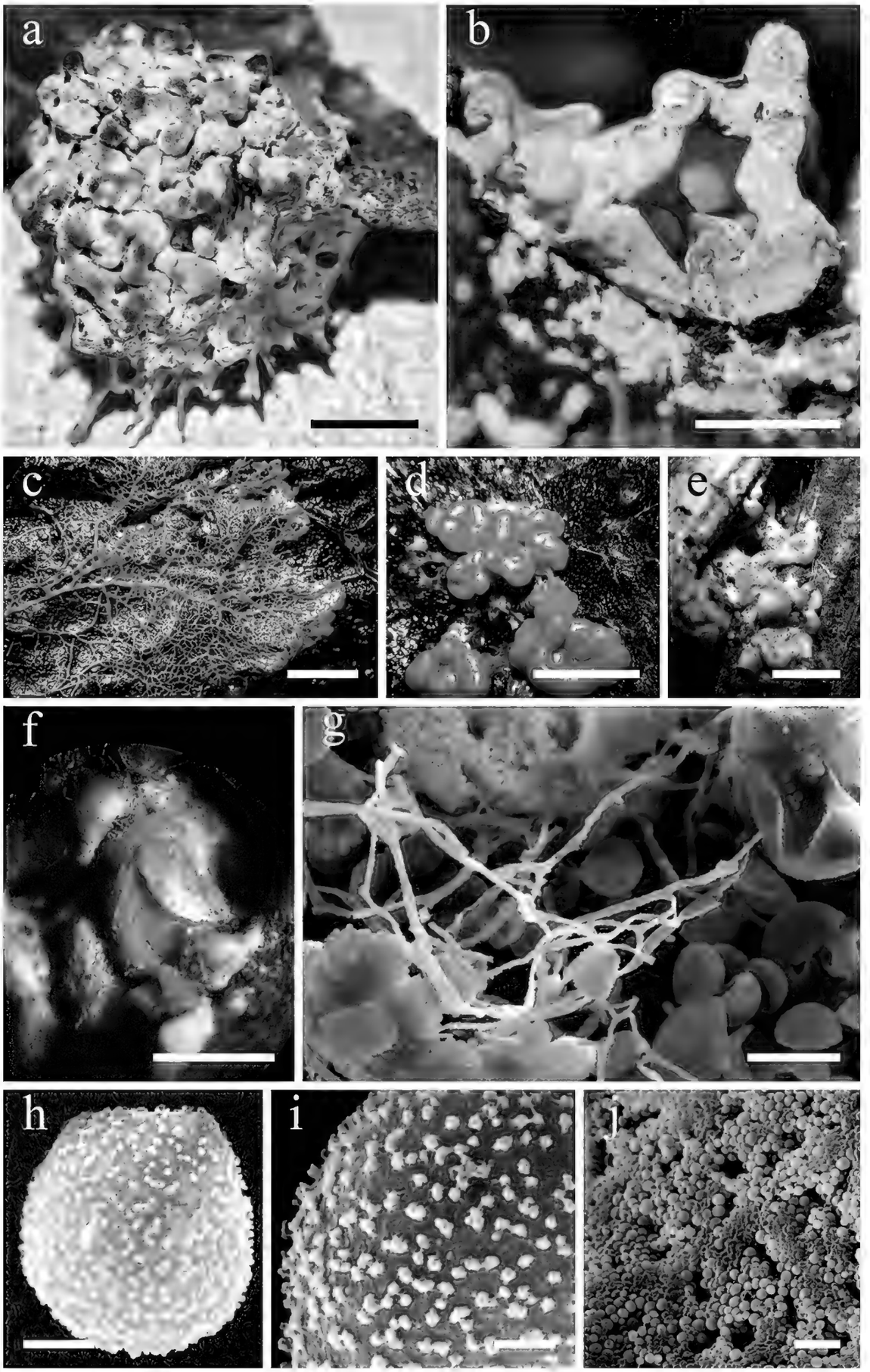
Ecology & distribution: Epiphytic on bark of living trees. Previously known from Europe (France), Asia (Bhutan, India, Indonesia), and Australasia (New Zealand) (Nannenga-Bremekamp 1984, GBIF on-line 1) with fewer than ten records worldwide. This represents a first record for Russia.

Comments: *Stemonitis rhizoideipes* sporocarps were retrieved from 33 Petri dishes. This species is distinguished from others in *Stemonitidaceae* by its very thin long isolated and unconnected sporangia and rounded peridial remnants (also found in *Symphitocarpus*). Our SEM study of *S. rhizoideipes* morphology did not reveal any differences from the original description. SEM photos of *S. rhizoideipes* microstructures were obtained here for the first time.

Fuligo aurea (Penz.) Y. Yamam., Myxomyc. Biota Japan: 390 (1998) Fig. 2

Plasmodiocarps sessile, branched, often merging together, sometimes remaining individual, yellow, grey-yellow, or almost white with yellow speckles. Peridium single, pale yellow to whitish yellow, bearing deposits of yellow or ochraceous lime. Stalks, when present, yellow, filiform, merging with hypothallus strands. Columella absent. Capillitium elastic,

Fig. 2. *Fuligo aurea* (NSK 1030738): a, b. Plasmodiocarps (RL); c. Plasmodium (RL); d–f. Macrocysts at different stages of maturation (RL); g. Capillitium, spores (SEM); h. Spore (SEM); i. Spore surface ornamentation (SEM); j. Calcium granules from the nodes of capillitium (SEM). Scale bars: a = 1 mm; b = 0.5 mm; c = 0.5 cm; d, e = 0.5 mm; f = 0.2 mm; g = 10 μm; h = 2 μm; i = 1 μm; j = 5 μm.


a
b
c
d
e
f
g
h
i
j

composed of a persistent net of colourless tubules; capillitial junctions mostly limeless but bearing a few yellow fusiform calcareous nodes. Spore mass black or brownish black. Spores pale violaceous brown, minutely punctate, 7–8 μm diam. Plasmodium yellow; macrocysts orange.

Specimen examined: **RUSSIAN FEDERATION, Khanty-Mansi Autonomous Okrug–Yugra, Khanty-Mansiysky district,** 22 km north-east of Khanty-Mansiysk, near Shapsha settlement, 61.0664°N 69.4689°E, 40 m, secondary deciduous forest, on bark of living *Abies sibirica*, substrate samples collected 28 September 2017, N.V. Filippova, moist chamber culture 04 March 2018, cult. and ident. A.V. Vlasenko (NSK 1030738).

Ecology & distribution: Lignicolous on dead wood of deciduous and coniferous trees. We isolated *Fuligo aurea* from the bark of a living tree as an epiphyte for the first time. Distributed in Europe (Sweden), Asia (Japan, Taiwan, Thailand, Philippines, Indonesia, Malaysia, India), Australasia (Australia, New Zealand), Africa (Reunion), North America (Mexico), and South America (Venezuela) (Yamamoto 1998, Stephenson 2003, Kylin & al. 2013, Liu & Chang 2012, Dagamac & dela Cruz 2015, GBIF on-line 2, GBIF on-line 3). This represents a first record for Russia.

Comments: Sporocarps of *Fuligo aurea* were retrieved from one Petri dish. The specimen appeared after 1.5 years of cultivation in a moist chamber. Observations of the large yellow *F. aurea* plasmodium over a lengthy period revealed that two months after initiating cultivation, macrocysts several times appeared for short periods before transforming back into the plasmodial stage. These macrocysts, which were bright, yellow-orange, 0.2–1 cm diam., diam., were observed in five moist chambers. Plasmodia transformed into plasmodiocarps in only one moist chamber. As myxomycetes growing in moist chambers may differ morphologically from samples collected in the field (Haskins & Wrigley de Basanta 2008), we publish a revised description for *F. aurea* based on newly observed morphological features. In some specimens, peridium had not only yellow colouration, but also greyish yellow. *Fuligo aurea* and *Physarum gyrosum* Rostaf. both develop sessile sporocarps with a grey peridium that are branched and often merge together, but the structure of the capillitial calcareous nodes distinguish the two species: those in *Ph, gyrosum* are white and tough, contrasting with the yellow nodes that expand to several times their original size upon the disintegration of the peridium. We are the first to record and describe macrocysts in *F. aurea*.

Comatricha anomala Rammeloo,
Bull. Jard. Bot. Univers. Belgrade 46: 237. (1976) FIG. 3

SPOROCARPS in groups on a common hypothallus; typically 1.5–2.5 mm tall overall in which the sporotheca is cylindrical with a rounded wider base and rounded narrower top, dark brown, and with a stalk 25–50% of total height; more rarely small the sporocarp is smaller (≤0.7 mm tall overall) and the sporotheca spherical with stalk 50–75% of total height; for both sizes STALK not hollow, fibrous, black (almost opaque in TL), rarely reddish-brown at the base. HYPOTHALLUS is common to each group, clearly visible, membranous, dark brown, meshed or folded, shiny at the stalk base, yellowish-brown in TL, with appendages in the form of stretched ropes. COLUMELLA a continuation of the stalk inside the sporangia, opaque, pointed at the top, not reaching the sporothecal tip but splitting at the apex into two or three main capillitial branches. PERIDIUM rapidly disintegrating, not preserved after maturation. CAPILLITIUM dense and brown, forming a large-mesh surface net, which protrudes into smaller individual meshes (≤5 μm diam.) on the periphery; capillitium containing many free ends ≤15(–35) μm long. SPORE MASS brown. SPORES globose, light greyish brown in TL, 7.5–9 μm diam., ornamented with warts, some forming 3–4 small incomplete reticulations on spores with small meshes. PLASMODIUM not observed.

SPECIMENS EXAMINED: **RUSSIAN FEDERATION, KHANTY-MANSI AUTONOMOUS OKRUG–YUGRA, Khanty-Mansiysky district,** 22 km north-east of Khanty-Mansiysk, near Shapsha settlement, Elevated bog "Chistoe", 61.0669°N 69.4567°E, 36 m, forested bog community with dominant *Pinus sylvestris* and cover of dwarf shrubs and *Sphagnum*, on bark of living *Pinus sylvestris*, substrate samples collected 01 October 2017, N.V. Filippova, moist chamber culture 04 March 2018, cult. and ident. A.V. Vlasenko (NSK 1030750); 22 km south-west of Khanty-Mansiysk, near the Mukhrino Field Station of Ugra State University, elevated bog "Mukhrino", 60.8947°N 68.6831°E, 40 m, forested bog community with dominant *Pinus sylvestris* and cover of dwarf shrubs and *Sphagnum*, on bark of living *Pinus sylvestris*, substrate samples collected 13 October 2017, N.V. Filippova, moist chamber culture 04 May 2018, cult. and ident. A.V. Vlasenko (NSK 1030746).

ECOLOGY & DISTRIBUTION: Epiphytic on bark of living trees. Distributed in Europe (Austria, Belgium, France, Germany, Italy, Norway, Malta, Portugal, Spain), Asia (Russian Federation [Novosibirsk Region]), and North America (USA, Mexico, Cuba) (Rammeloo 1976, Johannesen 1984, Kowalski & Demaree 1987, Moreno & al. 1992, Lizárraga & al. 1997, Briffa & al. 2000, Neubert & al. 2000, Camino & al. 2008, Vlasenko & Vlasenko 2020, GBIF

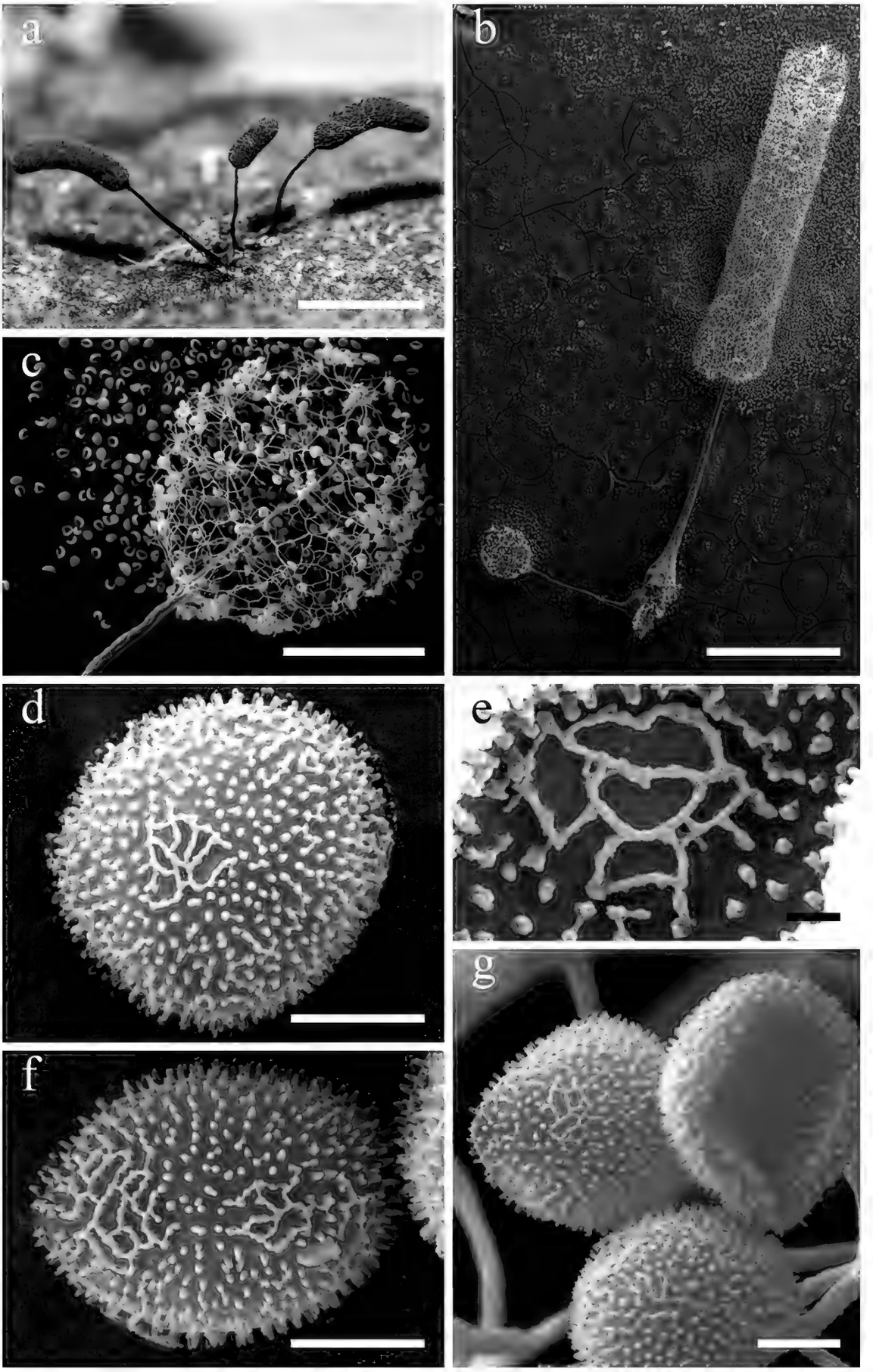

a
b
c
d
e
f
g

Fig. 3. *Comatricha anomala* (NSK 1030750): a. Sporocarps with typical cylindrical sporotheca (RL); b. Sporocarp with typically cylindrical large sporotheca and sporocarp with atypically spherical small sporotheca (SEM); c. Small spherical sporotheca with capillitium and spores (SEM); d. Spore (SEM); e. Spore surface ornamentation (SEM); f. Spore (SEM); g. Spores and capillitium (SEM). (NSK 1030741):. Scale bars: a = 1.5 mm; b = 500 μm; c = 100 μm; d = 3 μm; e = 500 nm; f, g = 3 μm.

on-line 4). This is the second record of *Comatricha anomala* in Russia; previously recorded in the Novosibirsk Region (Vlasenko & Vlasenko 2020).

Comments: *Comatricha anomala* sporocarps retrieved from three Petri dishes enabled us to identify some new morphological features not included in Rammeloo's type description. Here, atypical *C. anomala* sporocarps producing spherical sporotheca were identified for the first time. Spore size and ornamentation in samples with spherical and cylindrical sporotheca are completely identical, and both typical and atypical sporocarps were derived from the same plasmodial group. The sporocarps producing spherical sporotheca might be confused with sporocarps of *C. laxa* Rostaf., also characterized by spherical sporotheca. *Comatricha anomala* and *C. laxa* can be distinguished only by spore ornamentation as seen under SEM, making SEM essential for species identification. Spores of *Comatricha laxa* are ornamented with warts, while those of *Comatricha anomala* produce some that form small incomplete reticulations with small meshes.

Acknowledgments

The research of V.A. Vlasenko and A.V. Vlasenko was carried out as a part of the State Task for the Central Siberian Botanical Garden, the Siberian Branch of the Russian Academy of Sciences, project AAAA-A21-121011290024-5. Herbarium specimens were deposited into MG Popov Herbarium (NSK), USU 440537, Novosibirsk. The authors thank Daria Erastova (The University of Auckland, New Zealand) and Yang Gao (Jiangxi Agricultural University, Nanchang, China) for presubmission review.

Literature cited

Briffa M, Moreno G, Illana C. 2000. Some rare myxomycetes from Malta. Stapfia 73: 151–158.

Camino M, Moreno G, Castillo A, Mitchell DW, Minter DW. 2008. Additions to the myxomycete biota of Cuba. 1. Mycotaxon 106: 75–102.

Dagamac NHA, dela Cruz TEE. 2015. Myxomycetes research in the Philippines: updates and opportunities. Mycosphere 6(6): 784–795. https://doi.org/10.5943/mycosphere/6/6/12

GBIF (on-line 1): *Stemonitis rhizoideipes* Nann.-Bremek., R. Sharma & K.S. Thind. – GBIF Secretariat, Copenhagen. Accessed 28 May 2022: https://www.gbif.org/ru/species/5425744

GBIF (on-line 2): *Fuligo aurea* (Penz.) Y. Yamam. – GBIF Secretariat, Copenhagen. Accessed 28 May 2022: https://www.gbif.org/ru/species/5426025

GBIF (on-line 3): *Erionema aureum* Penz. – GBIF Secretariat, Copenhagen. Accessed 28 May 2022: https://www.gbif.org/ru/species/5426026

GBIF (on-line 4): *Comatricha anomala* Rammeloo – GBIF Secretariat, Copenhagen. https://www.gbif.org/ru/species/3213106 [accessed 28 May 2022]

Gilbert HC, Martin GW. 1933. Myxomycetes found on the bark of living trees. University of Iowa Studies in Natural History 15: 3–8.

Härkönen M. 1977. Corticolous myxomycetes in three different habitats in southern Finland. Karstenia 17: 19–32. https://doi.org/10.29203/ka.1977.121

Haskins EF, Wrigley de Basanta D. 2008. Methods of agar culture of myxomycetes—an overview. Revista Mexicana de Micología 27: 1–7.

Johannesen E. 1984. New and interesting myxomycetes from Norway. Nordic Journal of Botany 4: 513–520. https://doi.org/10.1111/j.1756-1051.1984.tb02057.x

Kowalski DT, Demaree RS. 1987. *Comatricha anomala*, a new record for the western hemisphere. Mycologia 79(1): 140–141. https://doi.org/10.1080/00275514.1987.12025380

Kylin H, Mitchell DW, Seraoui EH, Buyck B. 2013. Myxomycetes from Papua New Guinea and New Caledonia. Fungal Diversity 59: 33–44. https://doi.org/10.1007/s13225-012-0180-y

Lado C. 2021. An on line nomenclatural information system of *Eumycetozoa*. Real Jardín Botánico, CSIC. Madrid, Spain. http://www.nomen.eumycetozoa.com/data/index.php [accessed April 2021].

Liu CH, Chang JH. 2012. Six genera of *Physaraceae* (*Myxomycetes*) in Taiwan. Taiwania 57(3): 263–270.

Lizárraga M, Moreno G, Illana C. 1997. The myxomycetes from Baja California (Mexico). I. Mycotaxon 63: 287–300.

Moreno G, Illana C, Heykoop M. 1992. Spanish myxomycetes. VI. Four interesting species belonging to *Stemonitales*. Cryptogamie, Mycologie 13: 295–303.

Nannenga-Bremekamp NE, Yamamoto Y, Sharma R. 1984. *Stemonaria*, a new genus in the *Stemonitaceae* and two new species of *Stemonitis* (myxomycetes). Proceedings van de Koninklijke Nederlandse Akademie van Wetenschappen Section C. 87: 449–469.

Neubert H, Nowotny W, Baumann K, Marx H. 2000. Die Myxomyceten Deutschlands und des angrenzenden Alpenraumes unter besonderer Berücksichtigung Österreichs. Band 3: *Stemonitales*. Karlheinz Baumann Verlag, Gomaringen.

Rammeloo J. 1976. *Comatricha anomala*, a new myxomycete from Belgium. Bulletin du Jardin Botanique National de Belgique 46: 237–240. https://doi.org/10.2307/3667418

Stephenson SL. 2003. Myxomycetes of New Zealand. Fungi of New Zealand/Ngā Harore o Aotearoa, vol. 3. Fungal Diversity Research Series 11. 238 p.

Vlasenko A, Vlasenko V. 2020. First Asian record of *Comatricha anomala*, a rare epiphytic corticolous myxomycete. Karstenia 58(1): 10–15. https://doi.org/10.29203/ka.2020.485

Yamamoto Y. 1998. The myxomycete biota of Japan. 700 p.

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2022

April–June 2022—Volume 137, pp. 381–385

https://doi.org/10.5248/137.381

Elaphomyces leucosporus and *E. mutabilis*, new for Turkey

Yasin Uzun [1*] & Abdullah Kaya [2]

[1] *Department of Pharmacy Services, Ermenek Uysal & Hasan Kalan Health Services Vocational School, Karamanoğlu Mehmetbey University, 70400, Karaman, Turkey*

[2] *Department of Biology, Science Faculty, Gazi University, 06500, Ankara, Turkey*

[*] Correspondence to: *yuclathrus@gmail.com*

Abstract—*Elaphomyces leucosporus* and *E. mutabilis* have been determined as new records for the Turkish mycobiota, based on collections from Rize and Trabzon provinces. Brief descriptions and photographs related to their macro- and micromorphologies are provided.

Key words—biodiversity, *Elaphomycetaceae,* hypogeous ascomycetes, truffle-like fungi

Introduction

Of the 73 confirmed taxa of *Elaphomyces* T. Nees listed by IndexFungorum (2021), eight—*E. anthracinus* Vittad., *E. citrinus* Vittad., *E. cyanosporus* Tul. & C. Tul., *E. decipiens* Vittad., *E. granulatus* Fr., *E. leucocarpus* Vittad., *E. muricatus* Fr., and *E. septatus* Vittad.—have been recorded from Turkey (Uzun & Kaya 2021).

During routine field studies in Rize and Trabzon provinces of Turkey, some hypogeous macromycete samples were collected and identified as *Elaphomyces leucosporus* and *E. mutabilis*. After checking the current Turkish fungal checklist (Sesli & al. 2020) and subsequent contributions (Uzun & Kaya 2019, 2020, 2021, Uzun 2021), we found they represented new records for Turkey. This paper aims to contribute to the mycobiota of Turkey by adding new records.

Materials & methods

Ascocarps were collected from Rize and Trabzon provinces during 2017–2018. field studies. The fruitbodies were photographed in their natural habitats where necessary morphological and ecological observations were noted. After the specimens were transferred to the laboratory and dried in an air-conditioned room, the dried material was examined microscopically using a Nikon Eclipse Ci-S trinocular light microscope; SEM images were obtained by a Hitachi SU5000 scanning electron microscope. The specimens were identified with the help of Vittadini (1831), Dodge (1929), Hawker (1954), Zhang (1991), Montecchi & Sarasini (2000), Arroyo & al. (2005), Castellano & al. (2018), and Paz & al. (2012, 2017). The specimens are preserved in the fungarium of Department of Biology, Science Faculty, Karamanoğlu Mehmetbey University, Karaman, Turkey (KMU).

Taxonomy

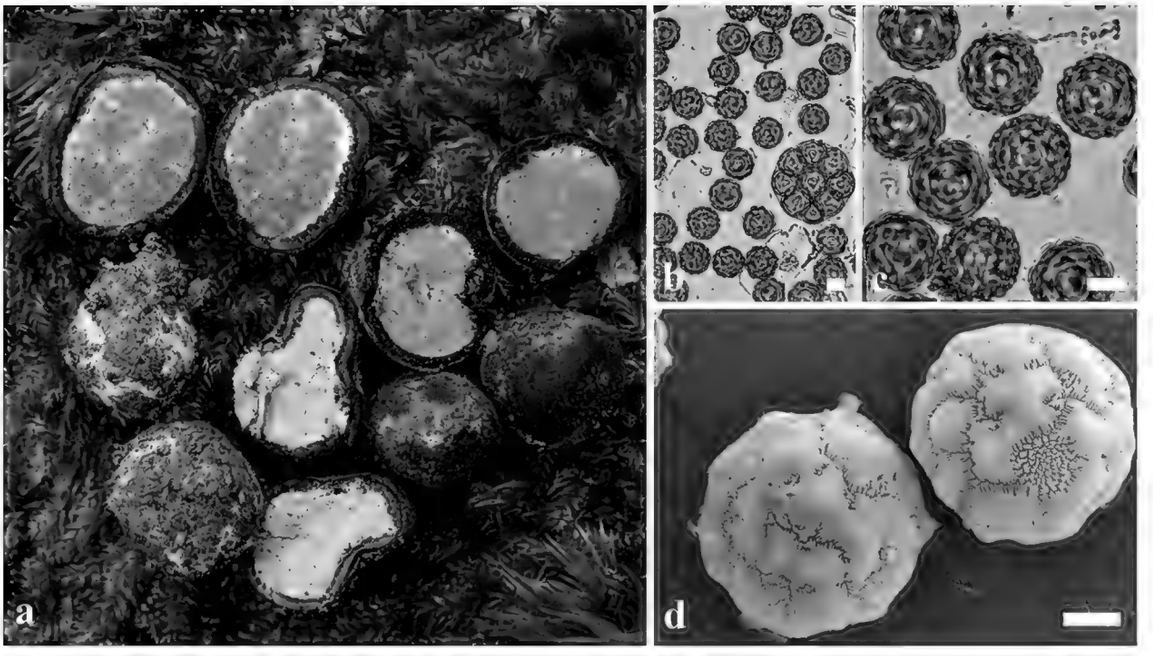


Fig. 1. *Elaphomyces leucosporus* (KMU-Uzun 6729).
a. ascocarps; b, c. ascospores (LM); d. ascospores (SEM).
Scale bars: b, c = 10 µm; d = 5 µm.

Elaphomyces leucosporus Vittad. Monogr. Tuberac.: 71 (1831) Fig. 1

Ascoma 5–10 mm diam., globose to spherical, some with an evanescent crust or a basal groove. Peridium thick, greyish brown to dark-brown or blackish, peridial surface dark brown to blackish, smooth, some slightly papillate. Gleba powdery, light milky-brown to dark coffee-brown. Asci spherical, 8-spored, rarely 4-spored. Ascospores 18–22 µm, spherical, pale yellow to yellowish-brown, covered with thick rods of irregular height that form a rough and wavy perisporium.

Specimen examined—**TURKEY, Trabzon, Esenyurt village**, 40.88°N 39.67°E, 745 m, in soil with greenish mycelium around *Fagus orientalis* and *Rhododendron ponticum* in broadleaved forest of *Castanea sativa, F. orientalis R. ponticum* and *Corylus* sp., 30.08.2018, Y.Uzun 6729 (KMU).

Comments—*Elaphomyces leucosporus* is regarded as an uncommon or a rare species (Hawker 1954). It is similar to *E. spirosporus* A. Paz & Lavoise in terms of fruit body morphology, spore size and attachment to a greenish mycelium, but the spores of *E. spirosporus* are covered with very short rods aligned longitudinally and forming spirals, while *E. leucosporus* produces spores with thick rods of irregular height that form a rough and wavy perisporium (Paz & al. 2012). Paz & al. (2017) commented on the marked preference of *E. leucosporus* for producing ascocarps in spring, but the Turkish collection was made during summer.

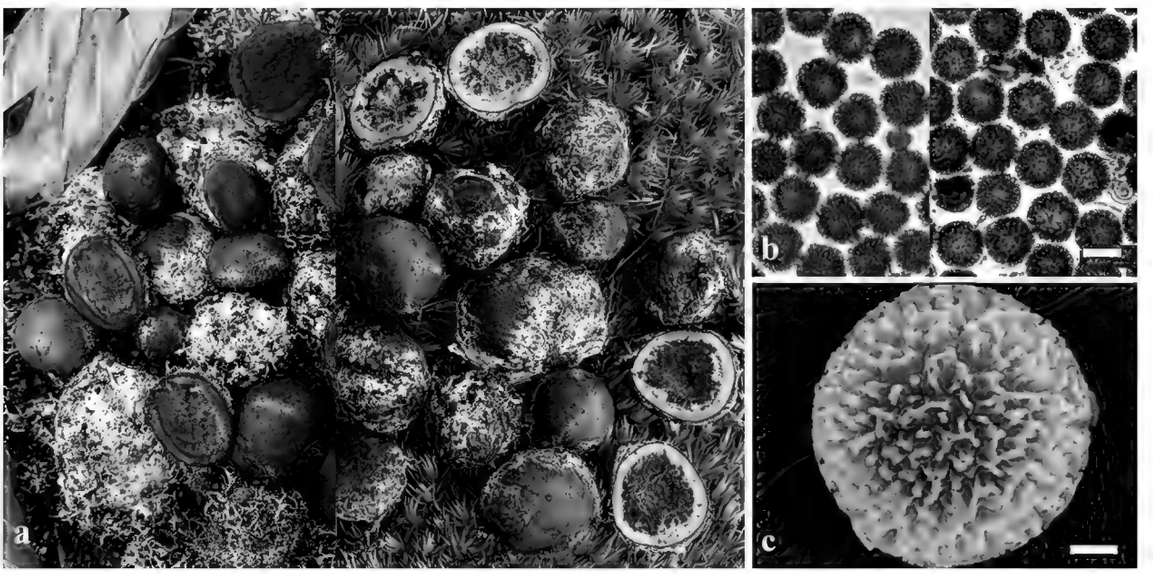


Fig. 2. *Elaphomyces mutabilis* (KMU-Uzun 6724).
a. ascocarps; b. ascospores (LM); c. ascospores (SEM).
Scale bars: b = 10 µm; c = 2 µm.

Elaphomyces mutabilis Vittad. Monogr. Tuberac.: 65 (1831) Fig. 2

Ascoma 8–20 mm diam., globose to subglobose, some depressed, generally encrusted with a white or white-ochraceous mycelial layer, rarely with uncovered partial surface areas; the surface beneath the mycelial layer smooth to minutely verrucose, dull, dark grey blackish to black. Odor weak, slightly fruity. Peridium 0.8–1.2 mm thick, whitish grey to bluish grey, with a thin blackish cortex. Gleba comprising a greyish blue powdery spore mass and whitish grey to grey bluish black hyphae. Asci globose. Ascospores

10–14 µm diam., globose to spherical, olive-green, blackish brown to black, ornamented with an irregular labyrinth formed by the anastomosing of fine spinelike or rodlike structures.

Specimens examined—**TURKEY, Rize, Ardeşen,** Ortaalan village, 41.17°N 41.10°E, 460 m, in soil under *Castanea sativa,* 11.08.2017, Y.Uzun 5748 (KMU); **Trabzon, Vakfıkebir,** Şenocak village, 40.95°N 39.28°E, 430 m, in soil under *C. sativa, Fagus orientalis* and *Rhododendron ponticum*, 20.02.2018, Y.Uzun 6193 (KMU); **Sürmene,** Yokuşbaşı village, 40.87°N 40.10°E, 340 m, in soil under *C. sativa, F. orientalis* and *R. ponticum*, 29.08.2018, Y.Uzun 6724 (KMU).

Comments—In general, the morphological characters of our Turkish materials agree with those given in literature (Zhang 1991, Montecchi & Sarasini 2000, Arroyo & al. 2005). *Elaphomyces mutabilis* can be confused with *E. striatosporus* Kers during collection due to the dense crust formed by white mycelium, but *E. striatosporus* is distinguished by larger spores (14–17 µm) with 2–3 µm tall branched, long, and parallel aligned ridges (Paz & al. 2012). Note: Our report of *E. mutabilis* is cited in Solak & Türkoğlu (2022), published two months ago while this paper was in processing.)

Acknowledgments

The authors would like to thank Karamanoğlu Mehmetbey University Research Fund (02–M–15 and 16–M–16) for its financial support; Yücel Uzun, Doğancan Kuduban and Ömer Uzun for their kind help in field; Prof. Dr. İbrahim Türkekul (Gaziosmanpaşa University, Tokat, Turkey), Assoc. Prof. Dr. Ali Keleş (Yüzüncü Yıl University, Van, Turkey), and Dr. Shaun Pennycook (Nomenclature Editor, Mycotaxon) for their helpful comments and careful review.

Literature cited

Arroyo BM, Fernández JG, Calmaestra EP. 2005. Tesoros de nuestro montes. Trufas de Andalucía. Consejería de Medio Ambiente, Junta de Andalucía, Córdoba 352 p.

Castellano MA, Elliott TF, Trappe JM. 2018. Three new black *Elaphomyces* species (*Elaphomycetaceae, Eurotiales, Ascomycota*) from eastern North America with notes on selected European species. Fungal Systematics and Evolution 1: 1–12. https://doi.org/10.3114/fuse.2018.01.01

Dodge CW. 1929. The higher *Plectascales.* Annales Mycologici 27(3–4): 145–184.

Hawker LE. 1954. British hypogeous fungi. Cambridge University Press.

Index Fungorum. 2021. Search Index Fungorum. Accessed September 2021: http://www.indexfungorum.org/names/Names.asp

Montecchi A, Sarasini M. 2000. Fungi ipogei d'Europa. A.M.B. Fondazione Centro Studi Micologici, Vicenza.

Paz A, Lavoise C, Barrio L, Richard F, Moreau PA. 2012. Propuesta de dos nuevas especies del género *Elaphomyces*, dos primeras citas para la Península Ibérica y una clave de identificación de las especies del género para Europa. Boletín Micológico de FAMCAL 7: 85–104.

Paz A, Bellanger JM, Lavoise C, Molia A, Ławrynowicz M, Larsson E, Ibarguren IO, & al. 2017. The genus *Elaphomyces* (*Ascomycota, Eurotiales*): a ribosomal DNA-based phylogeny and revised systematics of European 'deer truffles'. Persoonia 38: 197–239. https://doi.org/10.3767/003158517X697309

Sesli E, Asan A, Selçuk F. (eds) 2020. Türkiye mantarları listesi. İstanbul: Ali Nihat Gökyiğit Vakfı Yayını [in Turkish].

Solak MH, Türkoğlu A. 2022. Macrofungi of Turkey—Checklist Volume III. İzmir: Bornova-İzmir. 426 p.

Uzun Y. 2021. *Elaphomyces anthracinus*, a new hypogeous ascomycete record for Turkish mycota. Anatolian Journal of Botany 5(1): 29–31. https://doi.org/10.30616/ajb.857752

Uzun Y, Kaya A. 2019. *Elaphomyces granulatus*, a new hypogeous ascomycete record for Turkey. KSU Journal of Agriculture and Nature 22(1): 85–88. https://doi.org/10.18016/ksutarimdoga.vi.466008

Uzun Y, Kaya A. 2020. *Elaphomyces citrinus* and *E. cyanosporus*, new for Turkey. Mycotaxon 135(2): 339–344. https://doi.org/10.5248/135.339

Uzun Y, Kaya A. 2021. First record of *Elaphomyces decipiens* for the mycobiota of Turkey. Mantar Dergisi/The Journal of Fungus 12(2): 134–137.

Vittadini C. 1831. Monographia tuberacearum. Typographia F. Rusconi, Milano.

Zhang BC. 1991. Revision of Chinese species of *Elaphomyces* (*Ascomycotina, Elaphomycetales*). Mycological Research 95(8): 973–985. https://doi.org/10.1016/S0953-7562(09)80095-6

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. © 2022

April–June 2022—Volume 137, p. 387

https://doi.org/10.5248/137.387

Regional annotated mycobiota new to the Mycotaxon website:

Abstract—The 50-page mycobiota, Current status of cercosporoid fungi of India by Sinha, Navathe, Kharwar, Wijayawardene, Dai, and Chand, may now be downloaded from Mycotaxon's mycobiota webpage. This review covering the occurrence and nomenclatural status of 1871 cercosporoid fungal species in India brings to 154 the number of free-access fungae uploaded or linked to:

http://www.mycotaxon.com/mycobiota/index.html

INDIAN SUBCONTINENT

India

Shagun Sinha, Sudhir Navathe, Ravindra N. Kharwar, Nalin N. Wijayawardene, Dong-Qin Dai, Ramesh Chand. Current status of cercosporoid fungi of India. 50 p.

Abstract—Cercosporoid fungi are important fungal pathogens significant for quarantine as well as bio-security regulations. This group of fungi also produces many secondary metabolites of pharmaceutical importance. Cercosporoid fungi have not been reviewed by sequence-based classification and identification in India. This review covers a total of 1871 cercosporoid fungi reported from India up to 2021. Currently, out of 1871, only 1252 cercosporoid fungi (67%) from India are accepted in global fungal databases. Most of the cercosporoid reported from India are based on the genus concept proposed by Deighton (1976), and most type specimens of these species are not available in the form of cultures for re-investigation and reevaluation of the holotypes.

Key words—*Mycosphaerellaceae,* culture collections, DNA barcodes, morpho-molecular taxonomy, sequence-based classification

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. © 2022

April–June 2022—Volume 137, p. 389

https://doi.org/10.5248/137.389

Regional annotated mycobiota new to the Mycotaxon website:

Abstract—The 139-page annotated and illustrated checklist by Clericuzio, Cantini, Vizzini, and Dovana covering 1619 basidiomycetes collected from Tuscany's Grosseto Province may now be downloaded from Mycotaxon's mycobiota webpage. This excellent contribution brings to 155 the number of free-access fungae uploaded or linked to: http://www.mycotaxon.com/mycobiota/index.html

EUROPE

Italy

Marco Clericuzio, Diego Cantini, Alfredo Vizzini, Francesco Dovana. Investigating the basidiomycete diversity of Grosseto province (Italy, Tuscany): an annotated check-list. 139 p.

Abstract—We present a list of 1,619 species of *Basidiomycota,* subphylum *Agaricomycotina,* growing in Grosseto province (Italy, Tuscany), obtained from our own collections and from literature data. Our study included a systematic census of 18 sampling sites distributed throughout the province. Details of habitat and frequency are presented for each species. We recognized six categories of species frequency, i.e. rare, uncommon, occasional, fairly frequent, locally common and common, ranged in order of increasing commonness; rare species (defined as those occurring in less than 8% of sample sites) were the majority, accounting for more than 40% of the total. Native habitats inside the province were divided into four large vegetation units: evergreen Mediterranean vegetation, thermophile deciduous oak woods, mixed mesophile broad-leaved woods, and beech woods; conifer woods, being mainly introduced, were considered in separate units. The thermophile deciduous oak woods displayed the maximum fungal biodiversity, with 656 records, followed by the mixed mesophile broad-leaved woods (592), by Mediterranean evergreens (580), and finally by beech woods (217); conifer woods had 303 records, divided into 136 for coastal pines and 167 for mountain conifers. Two new species, *Tephrocybella constrictospora* and *Cortinarius lentus* (proposed elsewhere), were discovered in the course of this work, and some species new to Italy were noted, such as *Crepidotus macedonicus, Tephroderma fuscopallens* and *Cortinarius chailluzi.*

Key words—*Agaricomycetes,* Apennines, deciduous oak woods, fungal biodiversity, fungal ecology, Mediterranean habitats, species frequency

MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. © 2022

April–June 2022—Volume 137, pp. 391–397

https://doi.org/10.5248/137.391

Book reviews and notices*

Lorelei L. Norvell[1A] & Else C. Vellinga[2B]

[1] *Pacific Northwest Mycology Service, Portland, OR 97229, U.S.A.*

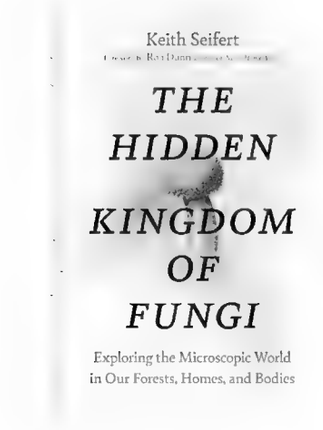
[2] *UC Herbarium, Berkeley, CA 94720, U.S.A.*

Correspondence to: [A]*llnorvell@pnw-ms.com* [B]*ecvellinga@comcast.net*

Abstract—Books reviewed include General—The Hidden Kingdom of Fungi (Seifert 2022) and *Basidiomycetes*—The boletes of China: *Tylopilus* s.l. (Chun & Yang 2021).

General

The Hidden Kingdom of Fungi—Exploring the Microscopic World in Our Forests, Homes, and Bodies. By Keith Seifert. 2022. [Greystone Books, Vancouver/Berkeley/London. 280 p. with line drawings, hardback. ISBN 978-1-77164-662-8 (cloth); ISBN 978-1-77100-663-5 (epub). Price (excl. postage): CAD34.95; USD27.95]



Fungomorphism rocks! (Or so I am now persuaded.) After leaving the art world to return to school 35 years ago for formal biological training, I was warned by Botany Professor Ed Lippert that scientists must not think 'teleologically,' inferring a purpose or design from natural phenomena where there was none. Imparting human feelings to life forms was right up there with falsifying experiment results. However, as Keith Seifert notes in his introduction, "Interpreting the behavior of

* Book reviews or books for consideration for coverage in this column should be sent to the Editor-in-Chief <editor@mycotaxon.com> 6720 NW Skyline, Portland OR 97229 USA.

other living beings as equivalent to human cognition, emotion, or agency is anthropomorphism. In science, this is often considered an unforgiveable error. But the very notion of anthropomorphism seems anthropomorphic. We too are locked into our version of existence by our senses and consciousness. Anthropomorphism is the best tool we have to imagine creatures that are so dissimilar [as fungi].... To imagine our world from the point of view of a fungus is a challenge, but because this book is about fungi, I will be unapologetically fungomorphic." Seifert proceeds, describing the fungal kingdom as seen through the eyes of fungi. The knowledge dispensed during his journey is eminently accessible and endlessly fascinating. That it is comprehensive is only to be expected by someone with Keith's impressive background and experience.

A forward by Rob Dunn sets the stage: "Mycology is a dark art. Mycologists perceive things that others miss. They traffic in the scarcely visible." There follows "A note about names" where Keith trenchantly observes that trying to master fungal names is like "trying to follow characters in a Russian novel" [especially given their mutability and transience during this age of molecular discovery]. He rightly observes that students should use the names more as a "phone book for looking up the evolutionary address of the fungus"—a way to discover where a fungus began and where it might be headed. In his 10-page Introduction ('Diversity in the dust'), the former President of the International Mycological Association briefly covers his early life to explain how he ended up as an integral part of the 'Fungal Umwelt.' The remaining book, with lovely line drawings scattered here and there, is divided into three parts.

Part I: The Hidden Kingdom (pp. 13–57) begins with 'Life in the colonies' (1), which tackles fungal evolution from the beginning: "Life appeared about four billion years ago during the geological period we call the Precambrian Era. For the first two billion years, sometimes disparaged as the Boring Billions, all life forms had just one cell." The next 21 pages pull us forward from those one-celled critters to fungi with so many mating variants that "if you count each combination of variants as a different gender and do the math for some species, you end up with 23,000 genders." A lot of complexity to introduce in these first pages, but Keith does it magnificently. 'Life on the commons' (2: mutualism/ parasitism/ biological invasion) shifts from life forms to life strategies, exploring the various types of symbioses and antagonistic interactions. (Two favorite subheadings in this chapter: 'Commensalism: friends without benefits' and 'The gray margins: parasitic symbionts or pathogens?')

Part II: The Fungal Planet (pp. 57–174): the chapters covering (3) forests, (4) farming, (5) fermentation, (6) 'the secret house' (indoor environments) and (7) "holobiont ('the mycobiome and the human body') comprise the meat of the book and are packed with an impressive amount of information. My knowledge of endophytes was limited to discovering in the late 1990's that DNA conifer phylogenies were in reality phylotrees of *Lophodermium* (here nicknamed 'lopho'), endophytes universally present in pine needles. "Once DNA barcoding came along, we were shocked to discover that among all the cultures and DNA barcodes directly retrieved from plant tissue were thousands of species of endophytic fungi." One reviewer was saddened that only six and a half pages covered the endophytic fungi in forests in this book, but those pages broadened my knowledge considerably. Also discussed are epiphytes, endo-/ecto-mycorrhizae, *Armillaria* and other endemic tree diseases, the discovery and battle against the Dutch Elm disease (DED), the more restorative process of decay and nutrient cycling overseen by fungi, and the potential use of endophytes in biological control.

"Farming" (the 'seventh oldest profession') focuses on the "artificial ecologies created over centuries, as farmers tilled their soil, planted seeds, prayed for sun and rain, and agonized over failed crops long before the causes were understood." In their drive to produce ever larger yields, farmers managed to so alter the natural environment (killing off the beneficial fungi) that they "unwittingly disrupted many of the original biological connections." Here endomycorrhizal fungi (of the *Glomeromycota* and *Mucoromycota*) with their arbuscles and vesicles come into their own. "Unlike most ectomycorrhizal fungi, AM fungi have a promiscuous, open-arms policy towards their plant partners and form symbioses with many different plants. Thousands of plant species rely on only two or three hundred species of AM fungi." Next come the rusts: 'Rust Never Sleeps' presents a detective story of how agriculturalists sought rust (*Puccinia graminis*) control through eliminating the alternate hosts (wheat and barberry) and now confront the problem of warmer climate and the tendency of *Puccinia* to develop new pathogenic races (including Ug99, from Uganda) which scientists are developing resistance strains to combat. Also covered are aflatoxins (according to some estimates, aflatoxin kills more people than malaria), vomitoxins (*Fusarium,* causing highly toxic 'tombstone kernels' in affected maize), and the more benign *Beauveria* and *Nosema,* now being developed as biocontrols of harmful insect pests.

Bring on the beer!! 'Fermentation' covers food, drink, and compost, introducing what Seifert calls the sacred fungal trilogy of 'wine, cheese, and

chocolate.' Chocolate and coffee would not taste so delicious if they were not transformed by yeasts (and bacteria) to develop their "distinctive flavor and aroma."

'The Secret House' moves fungi indoors and into the 'built' environment. At one time Keith would go 'field' collecting with his vacuum cleaner in houses to record whatever species he could find. Anyone who has contended with *Serpula lacrymans* (dry rot) in the walls and beams or *Stachybotrys* black moulds in damp buildings knows that fungi are as at home in houses as in the outdoors. Seifert notes, "The meaningful biological divisions among fungi in the built environment are between moulds causing decay; moulds that amplify in wet places; moulds that amplify in dry places; and moulds causing allergies. Each zone of a house has its own guild of fungi that affects us in various ways." He points to house dust as the 'most conspicuous domestic reservoir of moulds.' Earlier researchers estimated that western homes harbored about ~100 fungal species (with only 40–50 in any one building), but when Seifert barcoded the fungi in HIS house's central vac system, his few tablespoons of dark gray powder scooped into sealed plastic bags yielded ~600 fungal species, including plant pathogens blown in from the yard, yeasts and moulds actively spoiling food, soil fungi, along with 'typical' house dust fungi. "The clear signals of conifer endophytes were a puzzle until a picture of our Christmas tree slid across my computer's screen saver and reminded me of all the needles vacuumed off the floor. There was also the faint signal, just three sequences of a poisonous *Amanita* species only ever seen in Japan. How did that get there?" In suggesting strategies to combat some of the more toxic fungi, Keith discourages using bleach, which dries into crystals that 'irritate the lungs and could be more troublesome than the fungus you are trying to get rid of." He ends this chapter with the cheerful thought: "The reality is that our buildings—like trees, crops, and humans—are mortal. Over time, saprobic fungi will turn all of our built environments into compost." Sic transit gloria.

Part II concludes with the "holobiont" and the Human Microbiome Project that investigated the microbes on and in our bodies. As "walking ecosystems," humans are not exempt: "Almost every living thing big enough to see—wild and domesticated animals, reptiles, fish, and all our friends and relatives—is a collection of symbionts.... Russian matryoshka nesting dolls must have been inspired by microbiology." We know that "bacteria contribute an extra 50,000 genes to keep our systems functioning," but Seifert feels that the contributions from fungal genes tend to be downplayed; he also points out that really only a tiny proportion of the millions of bacteria and fungi in our environment

are harmful, and that a healthy microbiome naturally balances the competing interests of individual microbes. One fascinating pearl of wisdom is that yeasts (*Melasezzia*) serve as skin protectors as well as sparking bothersome dandruff and (when things get out of balance) itchy eczema. *Candida* is believed to assist digestion, although as candidasis it usually is blamed for pathogenic reactions (thrush) and hospital contamination.

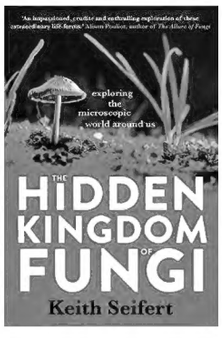
Part III: The Mycelial Revolution (pp. 177–218) presents two call-to-arms chapters. I confess to eyes glazing over somewhat during parts of 'Mycotechnology' (8), covering fungal involvement in the development organic aids, plastics, and enzymes, "mining" for drugs (the ever-fascinating Fleming-Florey-Chain-Mouldy Mary *Penicillium* saga and the development of cyclosporin), and mycoremediation, primarily because here the author preaches to the choir. Nonetheless he presents an effective call to action on how fungi can assist humans in restoring an increasingly elusive natural order. 'Thirty Thousand Feet' (9: fungi and the sustainable planet) tackles the problems presented by overpopulation, climate change, and all manner of political mayhem. This chapter is concluded by a rousing "The future is fungal. It is also bacterial, algal, protistan, viral, buggy, wormy—full of all sorts of creatures, the big and beautiful, the small and ugly. Most of the life-forms around us were here long before we arrived and will remain long after we are gone. Let's learn what we can from them and hope for a long, rich journey together."

The hidden kingdom of fungi concludes with the 'Acknowledgments' (pp 219–20), 'Appendix: Fungal classification' (pp. 221–31), 'Notes' (pp. 233–46), 'Literature cited' (pp. 247–64), and 'Index' (pp. 265–80). The 'Appendix' hits the high points of 2022 taxonomic/phylogenetic interpretations. Being a bit long in the tooth and decidedly species oriented, I customarily do not pay much attention to higher level taxa, so these ten pages were a bit of a welcome eye-opener (When did *Neocallimastigomycota* become a phylum? Sorry, Martha!) The Notes mix together fascinating tidbits and references. As a reader, I prefer notes placed at the bottom of the page but know from bitter experience that setting footnotes is a thankless task that modern editors and 'type-setters' avoid at all costs. I did miss text references placed in this section rather than in the running text; this particular placement frustrated my friend Jan (a just-the-facts reader and definitely not a fan of anthropomorphism), who really wanted to know the source of the information while reading. On the other hand, those unaccustomed to reading scientific papers truly despise finding a text reference plumped into the middle of the line, thus interrupting a really good story, so this

is probably the best compromise. Reading the notes all together before (and/or after) each chapter proved a good solution and drew attention to information that might have otherwise gone unnoticed.

Since 1992, I have had the supreme good fortune of knowing Keith and his friend Andy Mackinnon, two parts of the irreverent Rot Nots crew (their friend Richard Summerbell being the third), and have long forgiven Keith for once referring to this esteemed journal as "Mycotoxin" (which probably amused me more than it did founder Dick Korf). It's comforting to discover that the early Rot-Nots irreverent wit has sparked a book that everyone—mycologically trained or otherwise—should have on their bookshelves.

Lorelei L. Norvell
Pacific Northwest Mycology Service
Portland, Oregon 97229 U.S.A.
llnorvell@pnw-ms.com



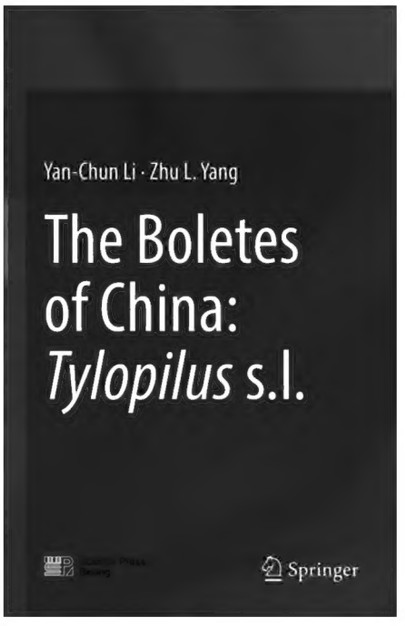
<—A different cover in Australia

Basidiomycetes

The Boletes of China: *Tylopilus* s.l. By Yan-Chun Li & Zhu L. Yang. 2021. [Springer, Address. 418 p. with plates & line-drawings; ISBN 978-981-16-2985-3 (hardcover $159.99, excl. postage) ISBN 978-981-16-2986-0 (eBook: $119). https://doi.org/10.1007/978-981-16-2986-0

The new Boletes of China is another testimony to the diversity and richness of bolete species in China. The focus here is on species with a pallid to pinkish, purplish pink, or red to reddish brown hymenophore and spore print; in other words, species that in the past would have been reckoned to the genus *Tylopilus*. These are here classified in a total of 19 genera, two of which are described as new to science. These 19 genera fall into five different subfamilies of the *Boletaceae,* so indeed, *Tylopilus* in the old sense, is polyphyletic to the nth degree.

To put this in perspective, new genera were also recently described for species in South America that conform to the traditional concept of *Tylopilus* (Magnago & al. 2022).



Chun & Yang, authors of the present book, state that in China alone many species that would have been assigned to *Tylopilus* sensu lato are still undescribed and await discovery, despite the fact that more than 100 species are covered here.

The book follows the traditional canvas of a taxonomic treatment: an introductory chapter, chapters on materials and methods, morphological characters of taxonomic importance, the phylogeny based on an analysis of several gene regions, and the taxonomic parts in which each genus gets treated in its own chapter, with keys to genera and species, and good illustrations (photos of all species in their natural habitat and—for the new species—line drawings of the important microscopical characters). A summary closes the book and of course a list of references and an index to the scientific names are present as well.

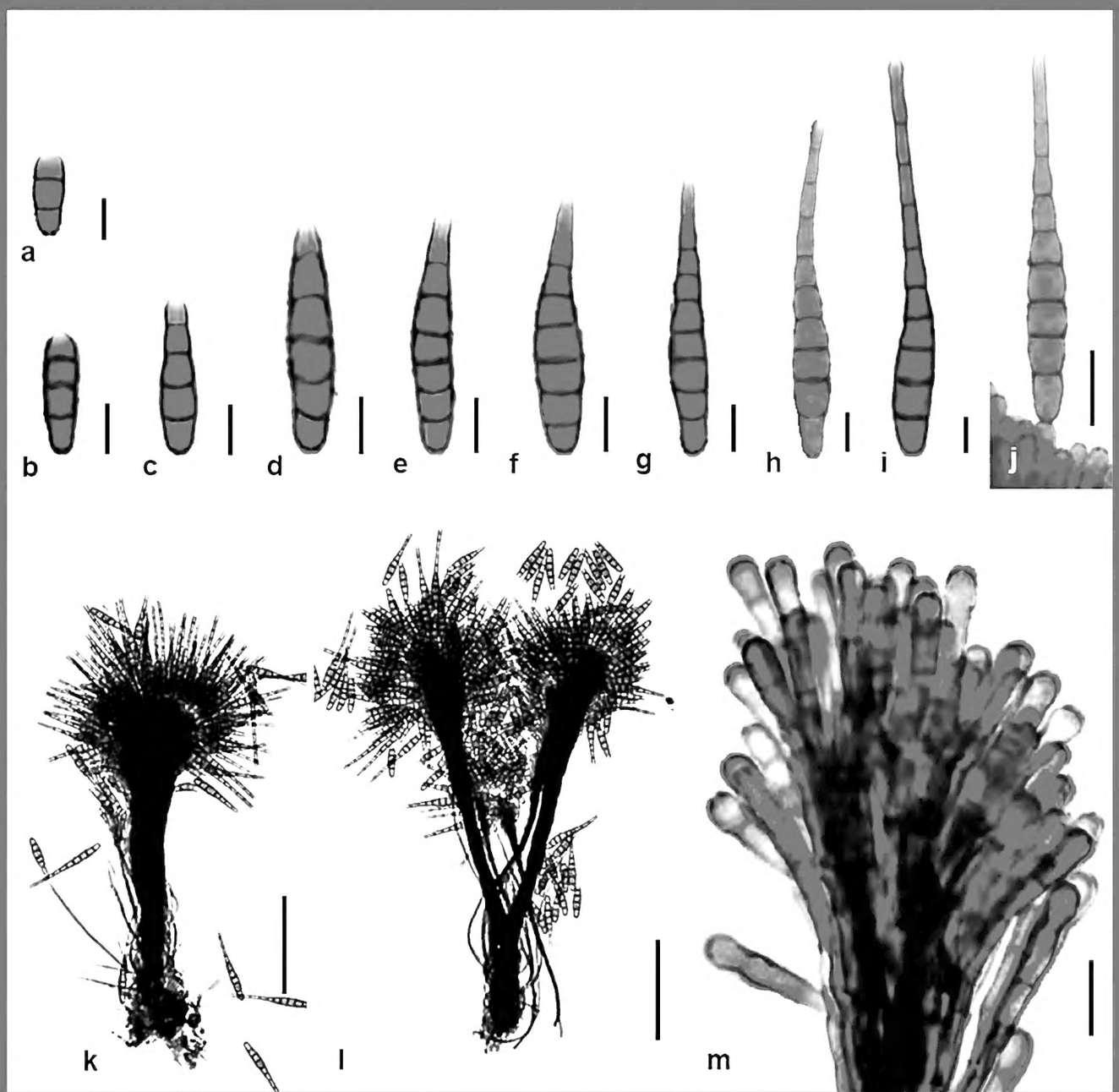
Of all the tylopoloid genera, with 32 species *Tylopilus* s.str. is the most species rich in China, of which 11 are described as new here. A wide variety of pileus and stipe colours are represented.

For many previously named species, new distribution data are provided that contribute important ecological information for taxa that often have been themselves only recently described. For instance, *Sutorius obscuripellis*, described in 2021 from northern Thailand, also grows in southern and southwestern China, and *Tylopilus himalayanus*, originally described from India is now also known to occur in several Chinese provinces.

This is a splendid effort to bring order to a group of species that at first glance might look very much alike. The authors can be congratulated on bringing the tylopoloids in such an organized manner to a wide public.

Magnago AC, Alves-Silva G, Henkel TW, Silveira, RM Borges da. 2022. New genera, species and combinations of *Boletaceae* from Brazil and Guyana. Mycologia 114: 607–625. https://doi.org/10.1080/00275514.2022.2037307

Else C. Vellinga
UC Herbarium, Berkeley, California, USA
ecvellinga@comcast.net



Podosporium simile sp. nov.
(Monteiro & al.— Fig. 3, p. 234)